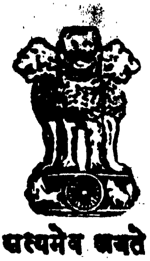

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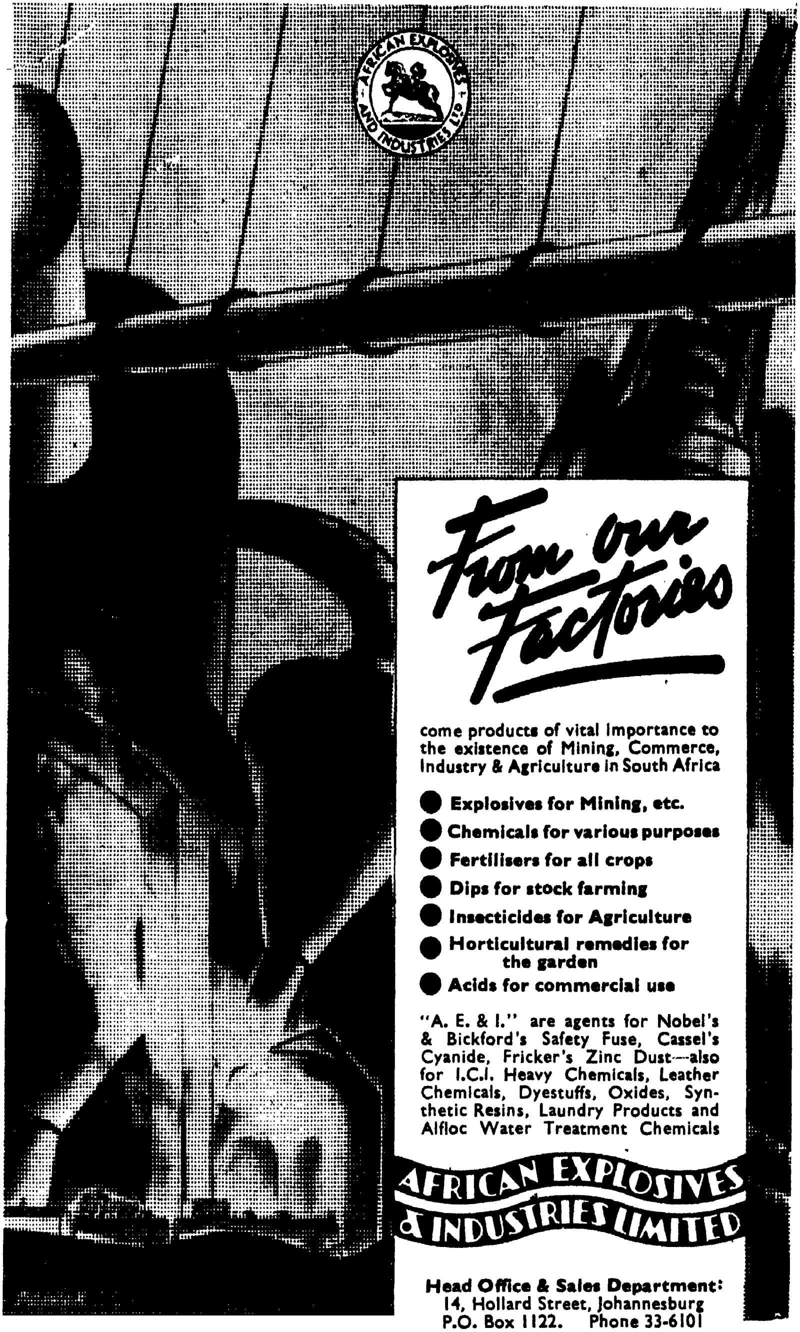

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THE

SOUTH AFRICAN JOURNAL OF SCIENCE

VOLUME XXXVIII

BEING THE

REPORT

OF THE

THIRTY-NINTH ANNUAL MEETING

OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE

JOHANNESBURG

1941

30th June and 1st July.

JOHANNESBURG:
PUBLISHED BY THE ASSOCIATION
and
Printed by SAMUEL GRIFFITHS AND CO., LTD. Dock Road,
Cape Town.

1942.

Form of Application for Membership

To the Assistant General Secretary,
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P.O. Box 6894, Johannesburg.

I desire to become *........................ member of the South African Association for the Advancement of Science, and for this purpose I enclose a cheque for £..................†

1. Name in full ....

2. Academic Degrees or Diplomas, Fellowships of Learned Societies, etc., held (if any) ....
(Note.—Academic qualifications, etc., are not indispensable.)

3. Profession or Occupation

4. Full Postal Address ......

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6. Proposed by ‡ ....

Date

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* Please state whether "Ordinary Member," "Life Member," or "Associate Member." Subscriptions are as follows: Life Members, £15; after ten consecutive years as an Ordinary Member, £7 10s. Ordinary Members, £1 10s. per annum. Associate Members, £1 for period of the Annual Session only. Student Members (not exceeding 23 years), 10s 6d. for period of Annual Session only. (Associate and Student Members are not entitled to receive the Journal of the Association.)

Certain back numbers of the Journal are now obtainable from the Hon. Librarian, University, Milner Park, Johannesburg, at a reduced rate.

Candidates resident in the Witwatersrand (Randfontein to Springs) should add the sum of £1 1s. for membership of the Associated Scientific and Technical Societies of South Africa.

† Cheques, etc., should be crossed and made payable to the Assistant General Secretary, South African Association for the Advancement of Science, and 6d. should be added to country cheques to cover exchange.

‡ In this respect the Assistant General Secretaries will be prepared to assist applicants.

SOUTH AFRICAN JOURNAL OF SCIENCE.

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THE

SOUTH AFRICAN JOURNAL OF SCIENCE

BEING THE REPORT OF THE

SOUTH AFRICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

(1941, JOHANNESBURG.)

Vol. XXXVIII. JANUARY, 1942. Vol. XXXVIII

EDITORIAL NOTE.

I have again been entrusted with the duty of seeing the *Journal* through the Press, and I desire to express my appreciation of the advice and assistance rendered me by the Honorary Editor of Publications, Professor John Phillips.

My thanks are also due to Professors L. F. Maingard and H. H. Paine for their kindly assistance, and to many authors for their consideration in promptly returning their proofs and in co-operating in any necessary modifications.

S. B. Asher

Hon. Associate Editor.

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PROCEEDINGS OF THE THIRTY-NINTH ANNUAL GENERAL MEETING OF MEMBERS, HELD AT KELVIN HOUSE, JOHANNESBURG, ON TUESDAY, 1st JULY, 1941, AT 12.15 P.M.

PRESENT: Mr. Jas. Gray, President, (in the Chair), Mr. S. B. Asher, Miss D. F. Bleek, Mr. E. C. Chubb, Professor R. H. Compton, Mr. H. H. Dodds, Dr. A. L. du Toit, Dr. R. A. Dyer, Mr. T. D. Hall, Dr. J. Hewitt, Mr. H. A. G. Jeffreys, Mrs. L. Jeffreys, Professor P. R. Kirby, Dr. F. E. T. Krause, Miss F. M. Lanham, Professor L. F. Maingard, Mr. B. D. Malan, Mr. B. T. Mennell, Mr. D. B. D. Meredith, Mr. A. G. Oettlé, Professor John Orr, Mr. F. R. Paver, Dr. E. Percy Phillips, Reverend Noel Roberts, Dr. J. B. Robertson, Professor G. H. Stanley, Dr. L. H. Wells, Miss E. E. Wijers, Dr. M. Wilman, Dr. H. E. Wood (Acting Honorary General Secretary), and Mr. A. J. Adams (Assistant General Secretary).

APOLOGIES: Dr. A. W. Bayer, Dr. E. J. Hamlin, Mr. A. J. Limebeer, Professor H. H. Paine, Professor John Phillips, Mr. J. H. Power and Mr. J. F. Schofield.

MINUTES: The Minutes of the Thirty-Eighth Annual Meeting, held at Johannesburg on the 2nd July, 1940, and printed on pages iii to v of the Report of the Johannesburg Session (Volume XXXVII of the Journal), were confirmed.

ANNUAL REPORT OF COUNCIL.—The Annual Report of the Council for the year ended 30th June, 1941, having been duly suspended on the Notice Board, was taken as read and adopted.

REPORT OF THE HONORARY GENERAL TREASURER AND STATEMENT OF ACCOUNTS.—The Honorary General Treasurer's Report and the Statement of Accounts for the year ended 31st May, 1941, having been duly displayed on the Notice Board, were taken as read and adopted.

HONORARY GENERAL SECRETARY.—The President stated that on the invitation of the Council Dr. H. E. Wood had kindly undertaken to act as Honorary General Secretary of the Association for the period of the Johannesburg Annual Session in the unavoidable absence of Professor H. H. Paine who had been called away from Johannesburg for military duties and of Dr. C. F. Juritz, who had been unable to come from Cape Town to attend the Johannesburg Annual Session

ELECTION OF GENERAL OFFICERS.—The following were elected as General Officers for the year 1941-1942:—

President: Dr. E. Percy Phillips.

Vice-Presidents: Dr. R. A. Dyer.
Colonel J. G. Rose.
Professor A. W. Bayer.
Dr. E. C. N. van Hoepen.

Honorary General Secretaries: Dr. C. F. Juritz and Professor H. H. Paine.

Honorary Treasurer: Mr. Jas. Gray.

Honorary Editor: Professor John Phillips.

Honorary Associate Editor: Mr. S. B. Asher.

Honorary Librarian: Mr. P. Freer.

Election of Council Members.—The following were elected as Council Members for the year 1941-1942:—

I. *Transvaal*: Mr. S. B. Asher, Mr. R. Craib, Mr. T. D. Hall, Dr. E. J. Hamlin, Mr. R. H. Harriss, Professor P. R. Kirby, Mr. A. J. Limebeer, Professor I. D. MacCrone, Professor L. F. Maingard, Professor John Orr, Mr. F. R. Paver, Dr. J. B. Robertson, Professor G. H. Stanley, Dr. L. H. Wells, Dr. R. Broom, Dr. P. J. du Toit, Dr. F. E. T. Krause, Dr. R. J. Ortlepp, Dr. A. Pijper, Dr. E. M. Robinson, Professor A. P. Goossens.

II. *Cape of Good Hope*: Colonel C. Graham Botha, Professor R. H. Compton, Mr. G. W. Lyon, Dr. B. de C. Marchand, Dr. S. H. Skaife, Dr. C. von Bonde, Mr. F. J. S. Anders, Professor C. G. S. de Villiers, Dr. L. D. Boonstra, Dr. P. W. Laidler, Dr. J. Hewitt, Mr. J. H. Power, Dr. M. Boehmke.

III. *Orange Free State*: Mr. F. W. Storey.

IV. *Natal*: Mr. F. G. Braithwaite, Mr. E. C. Chubb, Mr. J. F. Schofield, Dr. S. F. Bush, Dr. R. F. Lawrence.

V. *Southern Rhodesia*: Mr. H. B. Maufe.

The President proposed a hearty vote of thanks to retiring members of Council for their valuable services to the Association.

Appreciation of New President.—The President expressed the appreciation of members in their good fortune in having procured Dr. E. Percy Phillips as President of the Association for the ensuing year and he referred to the excellent work Dr. Phillips had done for the Association and for the advancement of science in South Africa. Under the able guidance of Dr. Phillips the Association could look forward to a year of great progress.

Dr. Phillips thanked the President for his kind remarks and expressed his appreciation of the honour which had been conferred on him in his election as President for the year 1941-1942.

Votes of Thanks.—On the proposal of Mr. E. C. Chubb, a unanimous vote of thanks was accorded to the Associated Scientific and Technical Societies of South Africa for providing the necessary accommodation for the holding of the Annual Session in Kelvin House and to the Press for their services in reporting the proceedings of the Session.

Mr. H. H. Dodds proposed a hearty vote of thanks to the President for the able manner in which he had conducted the Johannesburg Session and for the outstanding services he had rendered the Association during his term of office, this vote of thanks being received with acclamation.

In thanking Mr Dodds for his kind remarks, the President said he wished to place on record his appreciation of the help he had received from the staff of the Associated Scientific and Technical Societies of South Africa, and especially of the services rendered by Mr. A. J. Adams and Mr. I. M. Sinclair. He said that it also gave him great pleasure to see that Mr. and Mrs. H. A. G. Jeffreys were present at the meeting and he trusted that Mr. Jeffreys was enjoying his well earned retirement.

Annual Meeting—1942.—In view of the international situation, it was agreed that the Council have power to decide the venue of the 1942 Annual Meeting, or should it be deemed expedient to do so, to suspend the holding of an Annual Meeting next year.

The question was raised as to whether arrangements might not be made for the holding of the Annual Session at a different time of the year on account of the cold weather generally prevailing in the Union during the month of July. On the proposal of Professor John Orr, seconded by Miss D. F. Bleek, it was agreed that this matter be referred to the Council for its consideration and that the Council have power to act.

REPORT OF COUNCIL FOR THE YEAR ENDED 30th JUNE, 1941.

1. Obituary.—Your Council reports with regret the deaths of the following members: Mr. R. a-Ababrelton (Foundation Member). (died 1936); Major R. Ballantine, Adv. J. Tilson Barry, Dr. J. Burtt-Davy, Dr. J. H. L. Cloete, Sir William Dalrymple. Mr. R. Des Clayes, Mr. S. J. Hunter, Dr. E. T. Mellor (President 1926) Sir C. G. Smith, and of a former member Mr. J. R. Williams (Foundation Member and President of Section A, 1904).

2. Membership.—Since the last Report nine members have joined the Association, ten have died, and twenty-seven have resigned.

The following table shows the geographical distribution of membership as at the 30th June, 1941:—

Transvaal	316
Cape of Good Hope Province	155
Natal	77
Orange Free State	20
Southern and Northern Rhodesia	11
South West Africa	2
Moçambique	2
Abroad	22
	605

3. The Journal.—Volume XXXVII of the South African Journal of Science, comprising the Report of the Johannesburg Meeting, was placed in the hands of members in April, 1941. It consisted of 461 pages and contained 42 Papers (in full or in abstract) in addition to the Presidential Addresses.

4. Quarterly Bulletins.—Three Bulletins have been issued during the year under review, No. 1 in February, No. 2 in May, and No. 3 in June.

5. South Africa Medal and Grant, 1941.—On the recommendation of the South Africa Medal Committee consisting of Dr. H. E. Wood (Chairman), Dr. A. W. Bayer, Col. C. Graham Botha, Prof. C. G. S. de Villiers, Dr. A. L. du Toit, Prof. P. J. du Toit, Prof. P. R. Kirby, Prof. I. D. MacCrone, Prof. L. F. Maingard, Dr. E. P. Phillips, Dr. A. Pijper and Prof. M. M. Rindl, your Council has awarded the South Africa Medal, together with a grant of £56 19s. 7d., to Miss D. F. Bleek. The Secretary of the British Association has been notified of the award.

6. British Association Medal.—The Council of the British Association has decided that the ninth award of the Medal shall be made to Miss M. E. Malan for her Paper entitled "The Cranial Anatomy of the Genus Gerrhosaurus."

7. Donations.—The thanks of the Association are due to the Honourable the Minister of Mines, Education, Labour and Social Welfare for a grant of £250 towards the expenses of the publication of the Journal, and to the Johannesburg Municipality for a grant of £100

8. **List of Members.**—The Council published a new List of Members corrected to 30th November, 1940.

9. **Honorary Life Member.**—Dr. Theodore Reunert (Foundation Member) (President, 1905), was elected an Honorary Life Member of the Association.

It was on the initiative of Dr. Reunert that a meeting was called at Cape Town in 1901, which led to the formation of the Association.

10. **Resignation of Dr. H. E. Wood.**—In March, Dr. H. E. Wood tendered his resignation as Honorary General Secretary of the Association consequent upon his removal from Johannesburg to reside in the Cape Province. The Council accepted this resignation most reluctantly. It has placed on record its thanks for the valuable services Dr. Wood has rendered the Association as Honorary General Secretary for a period of 23 years.

11. **Annual Meeting, 1941.**—The Association was invited to hold the Annual Meeting for 1941 in Oudtshoorn, and this invitation was accepted by the Annual Meeting in 1940 with the proviso that the Council have power to arrange otherwise if deemed expedient in view of the international situation. After seeking the advice of all its members, the Council at its meeting on 15th November, 1940, decided to postpone the Oudtshoorn meeting and to hold a two day session in Johannesburg instead. A letter was sent to the Oudtshoorn Municipality announcing this decision and expressing the hope that the invitation might be left open and that the first meeting after the war might be held at Oudtshoorn.

12. **The New Council.**—On the basis of membership provided in the Constitution, Section 22, the numbers of members of Council assigned for the representatives of each Centre during the ensuing year should be distributed as follows:—

Transvaal:	
Witwatersrand	14
Pretoria	6
Outside	1
Cape of Good Hope Province:	
Cape Peninsula and Outside	6
Stellenbosch and District	2
East London and Port Elizabeth	1
Grahamstown, Kingwilliamstown and District	1
Kimberley	1
Oudtshoorn	1
Outside	1
Natal:	
Durban	3
Pietermaritzburg and Outside Districts	2
Orange Free State:	
Bloemfontein	1
Southern Rhodesia	1
Total	41

13. RETIRING MEMBERS OF COUNCIL.—The Council wishes to express its thanks to Professor R. A. Dart, Mr. H. H. Dodds, Dr. A. J. Hesse, Prof. W. J. Lutjeharms, Dr. R. H. Marloth, Dr. A. McMartin, Mr. G. O. Neser, Prof. M. M. Rindl, Professor C. van Riet Lowe and Prof. L. Verwoed, retiring members of Council who do not seek re-election, for their valuable service to the Council for many years.

14. HONORARY AUDITORS.—The thanks of the Association are due to Messrs. Alex Aiken and Carter, who have been Honorary Auditors to the Association for many years, for their services in carrying out the audit for the year 1940-1941.

15. SECRETARIAT.—The Associated Scientific and Technical Societies of South Africa have continued to carry out the secretarial work of the Association during the year, and the Council would like to put on record its appreciation of these services and especially of the services rendered by Mr. A. J. Adams and Mr. I. M. Sinclair.

REPORT OF HONORARY GENERAL TREASURER FOR THE YEAR ENDED 31st MAY, 1941.

The restriction on the duration of the Annual Meeting last year resulting in a reduction of the number of contributions presented has enabled me to report that the excess of revenue over expenditure for the year amounts to £363 6s. 0d. This turnover from the position last year when we congratulated ourselves on a deficit of only £32 14s. 2d. is also accounted for by reduced costs of printing—a reduction which is estimated at approximately £200. Then we have to record with thanks, a donation of £100 from the Johannesburg City Council. Apart from the assistance thus rendered to the finances of the Association this recognition of our work for the advancement of science in South Africa is very gratifying and encouraging.

Notwithstanding the drastic overhaul of our membership list in connection with members who had lost the habit of paying their subscriptions over a long period, the amount received in subscription dues is only £60 less than last year and in addition the fees for all members on active service have been remitted.

The other details of expenditure and revenue remain normal.

The necessity of husbanding our financial resources need not be emphasised, for in the aftermath of the war it is certain that difficult times lie ahead.

JAS. GRAY,

Honorary General Treasurer

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

BALANCE SHEET AT 31st MAY, 1941.

LIABILITIES.

	£	s.	d.	£	s.	d.
Sundry Creditors—						
General Accounts	21	0	9			
Grants to Local Centres under Rule 35	46	15	3			
Endowment Fund	18	18	10			
British Association Medal Fund	36	12	9			
Subscriptions Paid in Advance	16	10	0			
				139	17	7
Library Binding and Equipment Account—						
Balance at 31st May, 1940 ...	94	2	4			
Add Interest on Library Endowment Fund	74	14	9			
Library Deposits Forfeited ...	3	0	0			
	171	17	1			
Less Expenditure during year	70	10	7			
				101	6	6
Revenue and Expenditure Account—						
Balance at 31st May, 1940 ...	91	19	3			
Add Excess of Revenue over Expenditure for the year ended 31st May, 1941	363	6	0			
				455	5	3
				696	9	4
Endowment Fund				3,160	4	5
Library Endowment Fund ...				2,164	11	6
South Africa Medal Fund ...				1,617	16	3
British Association Medal Fund				486	12	9
				£8,125	14	3

ASSETS.

	£	s.	d.	£	s.	d.
Cash—						
At Bank	56	18	2			
At Post Office Savings Bank, with Interest accrued	37	1	10			
At St. Andrew's Building Society, with Interest accrued	412	17	9			
				506	17	9
Sundry Debtors—						
South Africa Medal Fund ...	6	13	0			
Library Endowment Fund ...	4	14	9			
For Advertisements in Journal	62	15	0			
For Reprints of Papers, etc.	58	3	0			
				132	5	9
Furniture				53	2	0
Medals on Hand				4	3	10
				696	9	4
Trustees' Endowment Fund—As per separate account				3,160	4	5
Library Endowment Fund—As per separate account				2,164	11	6
Trustees—South Africa Medal Fund—As per separate account				1,617	16	3
Trustees — British Association Medal Fund—As per separate account				486	12	9
				£8,125	14	3

We have examined the books and vouchers of the South African Association for the Advancement of Science for the year ended 31st May, 1941, and certify that in our opinion the above Balance Sheet correctly sets forth the position of the Association at the 31st May, 1941, according to the best of our information and the explanations given to us and as shown by the books.

JOHANNESBURG.
20th June, 1941.

ALEX. AIKEN & CARTER,
Auditors.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Dr. REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1941. Cr

		£	s.	d.	£	s.	d.
To Secretarial Fees					180	0	0
,, Journal Expenses		703	15	5			
Less Government Grant	£250 0 0						
,, Johannesburg Municipal Grant	100 0 0						
,, Sales, Reprints & Advertisements	152 5 7						
		502	5	7			
					201	9	10
,, Stationery and Printing ...					50	19	3
,, Postages					27	13	5
,, Expenses — Annual Meeting, 1940 (balance)		1	10	9			
,, Expenses — Annual Meeting 1941 (on account)		0	6	1			
					1	16	10
,, Sundry General Expenses ...					14	15	9
,, Grants to Local Centres under Rule 35—							
Witwatersrand ...	£24 6 3						
Cape Province ...	11 16 0						
Natal	10 13 0						
		46	15	3			
Less Grant outstanding for Orange Free State Centre for 2 years ended 31st May, 1940, unclaimed		4	9	0			
					42	6	3
,, Depreciation on Office Furniture					13	5	6
,, Pension—H. A. G. Jeffreys ..					90	0	0
,, Balance, being Excess of Revenue over Expenditure for year ended 31st May, 1941					363	6	0
					£985	12	10

	£	s.	d.	£	s.	d.
By Annual Subscriptions	576	18	0			
,, Arrear Subscriptions	267	7	0			
,, Students' Fees	0	7	6			
				844	12	6
,, Interest—						
On Endowment Fund	129	3	8			
On St. Andrew's Building Society Account	10	18	8			
On Post Office Savings Bank Account	0	18	0			
				141	0	4
				£985	12	10

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

ENDOWMENT FUND.

REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1941.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Interest, as per contra, transferred to General Fund	129	3	8	By Interest received during the year	129	3	8
,, Balance transferred to Accumulated Funds	37	10	0	,, Life Membership Subscriptions	37	10	0
	£166	13	8		£166	13	8

BALANCE SHEET AT 31st MAY, 1941.

LIABILITIES.	£	s.	d.	£	s.	d.
Accumulated Funds—						
Balance at 31st May, 1940 ...	3,122	14	5			
Add Amount transferred from Revenue and Expenditure Account	37	10	0			
				3,160	4	5
				£3,160	4	5

ASSETS.	£	s.	d.	£	s.	d.
Investments in Hands of Trustees—						
Cape Town Municipality 3¼% Stock	1,150	0	0			
Cape Town Municipality 4% Stock	300	0	0			
Cape Town Municipality 5% Stock	240	0	0			
Cape Town Municipality 5% Stock	800	0	0			
Port Elizabeth Municipality 3½% Stock	100	0	0			
Cape of Good Hope Savings Bank	551	5	7			
				3,141	5	7
Amount due from General Fund				18	18	10
				£3,160	4	5

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

LIBRARY ENDOWMENT FUND.

Dr. REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1941. Cr.

	£	s.	d.		£	s.	d.
To Balance transferred to Library Binding and Equipment Account	77	14	9	By Interest received during the year	74	14	9
				,, Library Deposits forfeited	3	0	0
	£77	14	9		£77	14	9

BALANCE SHEET AT 31st MAY, 1941.

Liabilities.	£	s.	d.	Assets.	£	s.	d.
Accumulated Funds—				*Investments*—			
Balance at 31st May, 1940	2,164	11	6	£2,000 City of Johannesburg 3¼% Local Registered Stock—At Cost	1,970	0	0
				Cash at St. Andrew's Building Society—			
				Savings Bank Account	194	11	6
	£2,164	11	6		£2,164	11	6

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SOUTH AFRICAN MEDAL FUND.

REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1941.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Expenses in connection with 1941 Award	6	13	0	By Interest received during the year … …	63	12	7
,, Amount of Award, 1941 … … … … …	56	19	7				
	£63	12	7		£63	12	7

BALANCE SHEET AT 31st MAY, 1941.

LIABILITIES.	£	s.	d.	ASSETS.	£	s.	d.
Sundry Creditors—				*Investments in hands of Trustees*—			
1941 Award and Expenses … … … … …	63	12	7	Fixed Deposit, South African Permanent Mutual Building and Investment Society … … … … … … … … …	1,609	13	6
Accumulated Funds—				*Post Office Savings Bank* … … … … … …	71	15	4
Balance at 31st May, 1940 … … … …	1,617	16	3				
	£1,681	8	10		£1,681	8	10

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE BRITISH ASSOCIATION MEDAL FUND.

Dr. REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1941. Cr.

	£	s.	d.		£	s.	d.
To Award	10	0	0	By Interest received during the year	16	17	6
,, Balance transferred to Accumulated Funds	6	17	6				
	£16	17	6		£16	17	6

BALANCE SHEET AT 31st MAY, 1941

Liabilities.	£	s.	d.	£	s.	d.	Assets.	£	s.	d.
Accumulated Funds—							*Investments in hands of Trustees*—			
Balance at 31st May, 1940 ...	479	15	3				£450 Union of South Africa 3½% Local Registered Stock 1948/58	450	0	0
Add Amount transferred from Revenue and Expenditure Account	6	17	6				*Amount due from General Fund*	36	12	9
				486	12	9				
				£486	12	9		£486	12	9

REPORT OF THE HONORARY LIBRARIAN FOR THE YEAR ENDED 31st MAY, 1941.

The Association's Library is housed in the Library of the University of the Witwatersrand, Johannesburg.

Hours of Opening—

Weekdays. Term: 8.30 a.m. to 6 p.m.
Vacation: 9 a.m. to 5 p.m.

Saturdays. Term: 8.30 a.m. to 12.30 p.m.
Vacation: 9 a.m. to 12.30 p.m.

Exchange of Publications. During the year the following names have been added to the exchange mailing list:—

Chicago academy of sciences.
Mysore university journal.

Donations. Gifts other than exchange material have been received from the following:—

The Director, Albany museum.

Guide to the vertebrate fauna of the eastern Cape Province. Pts. 1-2.

Dr. E. Jokl.

Jokl, E. The medical aspect of boxing.

Missouri botanical garden.

Steyermark, J. A. Spring flora of Missouri.

Dr. G. Potts.

Potts, G. Ecological study of a piece of Karroo-like vegetation near Bloemfontein.

Dr. A. Roberts.

Roberts, A. The birds of South Africa.

Royal Swedish Academy of Sciences.

Fries, E. Origin and foundation of the Royal Swedish Academy of Sciences.

Hildebrand, B. K. Svenska Vetenskapsakademien för historia. 2v.

Holmberg, A. Bicentenaire de l'Académie Royale des Sciences de Suède.

Southern Rhodesia. Parliament.

Parliamentary papers. 1939.

Binding. 94 volumes were bound during the year.

Stock. The Library now contains about 3,400 volumes. 232 titles are received currently.

ACCESSIONS TO SERIAL PUBLICATIONS, 1940/41.

For a Catalogue of serial publications in the Library, and Supplement, see this Journal, vol. 30, p. xxv—xxix and vol. 34, p. xxxiv—xxxvii. Subsequent accessions are listed in the Annual Reports.

Mysore. University.

Half-yearly journal. New series.
  Section A. Arts.
    1, 1940+

  Section B. Science.
    1, 1940+

Revista Mexicana de sociología.
  1, 1939+

P. FREER,
Honorary Librarian.

University of the Witwatersrand,
Johannesburg.
19th June, 1941.

In Memoriam

REV. SAMUEL SHAW DORNAN.

The death occurred on Sunday, the 27th July, of the Rev. Samuel Shaw Dornan, Superintendent of the Native Missions of the Presbyterian Church in the Transvaal.

The eldest son of the late Dr. William and of Mrs. Margaret Dornan, he was born 70 years ago at Carr, County Down, Northern Ireland. At first destined for the medical profession, he turned his attention to Theology and graduated at Dublin University.

He came to this country during the Boer War, in which he served, and subsequently joined the Paris Evangelical Mission in Basutoland. He then went to Rhodesia to help in laying the foundations of the Native Presbyterian Missions and looked after them for the next 15 years. But his health suffered and after a short period in Kimberley, he came to the Transvaal in 1924, where he devoted his life to mission work and greatly endeared himself to his native congregations.

Mr. Dornan will be remembered not only in his missionary capacity but for his work in the field of native customs and linguistics. He had a profound knowledge of the Sechuana and Sesuto languages in which he used to preach frequently, and while in Rhodesia he got to know the Bushmen of that country intimately. The result of his investigations is embodied in his well-known paper "The Tati Bushmen" published in the *Journal of the Royal Anthropological Society of Great Britain* in 1917 and in his fascinating book on the "*Pygmies and Bushmen of the Kalihari,*" London, 1925. He also contributed many papers on native lore to the *South African Journal of Science* (1912-1934) and represented Rhodesia on the Council of the South African Association for the Advancement of Science (1913-1920). While resident in Pretoria he lectured for a while at Pretoria University College, as it then was.

Nor do these activities exhaust the scope of his interests. He was an excellent mathematician and geologist, and during his stay in Basutoland he surveyed portions of the country for the government of the day. There seemed to be no limit to his fund of knowledge, while his brilliance as a conversationalist and his charm of manner added greatly to the many reminiscences with which he used to delight his friends. But it was the even more solid qualities of the heart which formed the chief characteristics of the man. His deep-seated honesty, his innate modesty and his straightforwardness impressed themselves on his life work, both as a scientific investigator and as a clergyman in the field. His friends feel that the world is the poorer by the loss of a " very parfait gentle knight " of the Christian religion.

L.F.M.

(*Reprinted by permission from 'Bantu Studies', Vol. 15, No. 3, Sep. 1941.*)

In Memoriam.

ERNEST EDWARD GALPIN, D.Sc., F.L.S.

Dr. Ernest Edward Galpin was born in Grahamstown in 1858 and died at Naboomspruit on the 16th October, 1941. In the death of Dr. E. E. Galpin, South African botanical science has lost the man referred to by Gen. J. C. Smuts as the "Prince of Collectors." As a youth he served in the Kaika-Galeka rebellion in 1877-78 and afterwards obtained employment in banking. Whilst in the service of the National Bank at Middelburg, C.P.. he took up the study of Systematic Botany as a hobby, but it was not until 1888, when he was transferred to Grahamstown that he commenced his herbarium. In 1889 he was stationed at Barberton where he remained three years and his collections from that area still constitute the most complete record we have of the local Flora. Galpin's principal collections were made when he was stationed at Queenstown where he remained for twenty-five years. He was a thorough collector and in a three months trip from Port Elizabeth to Cape Town he collected 1,500 species of plants. What little information we have of the high mountain vegetation (9,000-11,000 ft.) bordering Griqualand East and Basutoland we owe to him. Galpin was an unselfish collector and prepared thousands of duplicates which were distributed to Kew, Bolus, Medley Wood,, MacOwan, Schonland, and to Schinz at Zurich. In the year 1917 Galpin presented the whole of his valuable collection to the Union Government and it formed the foundation on which the present National Herbarium has been built. He is commemorated in the genus *Galpinia* named after him by the late Dr. N. E. Brown.

Galpin became a Fellow of the Linnean Society in 1890 and his scientific work was recognised by the University of South Africa in 1935 when the University conferred on him the degree of Doctor of Science, honoris causa. He published on the flora of the Drakensburg, on the native timber trees of the Springbok Flats and also published a botanical survey of the Springbok Flats.

Dr. Galpin was a Life Member of the Association which he joined as a member in the year 1903, the year after the foundation of the Association. He held office as a vice-President for the Transvaal and served on the Committee of Section C. He was a very regular attendant at the Annual Sessions and during his retirement trekked round the country collecting, planning his itinerary to end at the centre in which the Annual Session was being held.

As a man Dr. Galpin endeared himself to all with whom he came into contact. Notwithstanding his vast knowledge of the flora of South Africa he was unassuming and modest and his experience was freely given to those who sought it. No special request made to him for specimens of particular plants was ignored and no trouble or expense stood in his way. In his wife, who predeceased him, he had a wonderful helpmeet. She accompanied him on most of his trips and assisted with the preparation of his specimens. His end was peaceful and he has left us after leading a full and useful life. E.P.P.

In Memoriam.

ALEXANDER AIKEN, LL.D., F.S.A.A.

It is with great regret that we record the death of Dr. Alexander Aiken in Johannesburg on the 24th July, 1941, at the advanced age of 80 years. Eminent in Economics and Finance, Dr. Aiken was an enthusiastic supporter of Higher Education and greatly assisted in the foundation of the University of the Witwatersrand. He joined the Association for the advancement of Science in 1904, and acted as Honorary Auditor to the Association, in conjunction with his partner Mr. J. G. Carter, from October, 1920, to June, 1941, a period of 22 years.

Dr. Aiken was born in February, 1861, at Old Meldrum, Aberdeenshire, and came to South Africa in 1890. After some years work with the National Bank he commenced practice as an Accountant and Auditor in 1895. During the South African war he assisted the financial adviser to Lord Roberts, and in 1901 he accepted an invitation from Lord Milner to undertake the financial organisation of the newly-formed Municipality of Johannesburg, a task which resulted in the foundation for the city's financial soundness being well and truly laid.

Owing to his keen interest in Education Dr. Aiken joined in 1913 the Council of the South African School of Mines and Technology, the intermediate institution between the Transvaal University College (Johannesburg) and the University of the Witwatersrand. In 1915 he was elected to the Council of Education of the Witwatersrand and in 1916 he became one of the trustees of the University Committee which undertook to raise funds for the establishment of a University, and his efforts contributed in no small degree to the success of the Committee in raising the considerable sums which made the founding of the Witwatersrand University possible.

In 1922, the Transvaal Government appointed him a member of the Provincial Finances Commission whose findings influenced the succeeding Financial Relations Acts, and in 1923, at the request of the Johannesburg Municipality, he drew up the "Aiken Report" which forms the basis of the scheme of Municipal Employment.

In acknowledgment of his great services to higher education and of his eminence as an economic and financial expert, the University of the Witwatersrand conferred upon him the honorary degree of Doctor of Laws in 1928.

Among Dr. Aiken's publications may be mentioned:—"A Report on the finances of the Johannesburg Municipality" (1910); "A Report on Municipal Employment" (1923); "Notes on Unemployment" (1926); "The Income Tax" (1928).

LIBRARY

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XXXVIII, pp.* 1-16.
January, 1942.

THE SCIENTIST AS A CITIZEN

BY

JAS. GRAY,

PRESIDENT.

Presidential Address delivered 30th June, 1941.

For the second year in succession, it has been necessary owing to war conditions, to hold a short session of the Association in Johannesburg. While this procedure has restricted somewhat the purpose of the Association, nevertheless it has enabled the necessary business to be carried on, and the continuity of the proceedings maintained. With so many members engaged in active war work, in one direction or another, it is indeed satisfactory to be able to state that while no major developments can be reported, the sphere of influence of the Association has not been reduced. Though some may have hoped that collectively the Association might have added its quota to the war effort, this has not been possible. Indeed, apart from the medical and engineering sciences, apparently those in authority who are responsible for the conduct of the war have not felt any urge to utilize to any appreciable extent, the ability and knowledge of those citizens who practice the sciences other than those previously mentioned. It is not my purpose to discuss at this moment, which is not opportune, if this neglect is wise or unwise in these abnormal times, but one can say with confidence that such indifference on the part of administrators and their officers is not unusual in this country and elsewhere, in times of peace as well as in times of war. For the same reason the full resources of the democracies are not utilized to the greatest possible extent as they are in totalitarian states.

To men nurtured in a scientific atmosphere, freedom of thought, speech and movement is indispensable to the progress and advancement of science, and is the very essence of the scientific spirit. These ideals are embodied in that much used and abused word "democracy." Indeed it is axiomatic to say that no man of science who is true to himself and his science can do other than range himself unreservedly on the side of those who are fighting the evil forces which would take from us the privileges which connote all that is best in civilization, as we know and appreciate it. His duty and responsibility as a member of the State is clear and definite.

Nevertheless, there appear to be some, presumably educated and cultured people, who have allowed hate so to overrule their intelligence that they view with satisfaction and an exaltation of spirit any major or minor defeat which might tend to overthrow the forces of democracy and plunge the peoples of the world back into a condition of servitude. For a free people to contemplate a life in which individual thought is restricted and speech disciplined, is a prospect which one would think no educated person could view with tranquillity. The position is comprehensively summed up in the following resolution of the American Association for the Advancement of Science put forward about two years ago, viz.:—

"Science is wholly independent of national boundaries and races and creeds and can flourish only where there is peace and intellectual freedom."

What can we, not only as scientists, but also as citizens, do to ensure the recognition of this great truth?

Much ignorance exists in many Departments of State as regards the status of scientific men. This want of knowledge would be a cause for humour if it were not so pathetic. Chemists will recall that in the Great War of 1914-1918, both in Great Britain and in the Union their branch of Science was classified on the same grade as carpentry, plumbing, fitting and the like. While in no way snobbish one feels that there can be no excuse for such profound ignorance of the status of the chemist and his highly academic training. It may be that this lack of knowledge is in part responsible for the lavishness with which army commissions have been granted to persons about whom there could be a measure of doubt regarding the manner in which they might be expected to further the war effort.

Let me digress for a few moments to indicate the direction in which the science of chemistry is of paramount importance in war, because it may be that the unassuming modesty of the chemist and his neglect to advertise his wares and his attainments may be responsible for the humble position to which he has been assigned by those set in authority over us. It is essentially as a non-combatant that the chemist functions in war. The manufacture of munitions is primarily a chemical industry and as the antithesis to these death-dealing compounds, life-giving chemicals and drugs for the relief of the sick and wounded are also products of the science. In a word, the application of chemical science, in its various ramifications, places in the hands of those responsible for the conduct of war, forces for good and evil. While chemists accept no responsibility for the latter use, nevertheless in the hope of bringing peace nearer, the chemist in common with other scientists is anxious to be given an opportunity for his knowledge and abilities to be used to the fullest extent.

It has been said that this is an engineers' war. This is not so. It is a war which requires the knowledge and assistance of all branches of science. To-day, there is no clear line of demarcation between the various sciences—they are interdependent. In one direction or another each science contributes its quota towards the supply of weapons of war and the other essentials required in the equipment of a modern army, navy and air force.

Let us take a simple example which will indicate how incorrect it is to attribute to one science superiority over another. This is done in no carping spirit but merely " to point a moral or adorn a tale." Modern weapons of war are fashioned essentially from iron and steel. The geologist and the mining engineer indicate the whereabouts and the value of deposits of iron and the other ores required for the manufacture of iron and steel. The mining engineer controls the opening up of the deposit and the exploitation of the ore. The metallurgist, with a fundamental knowledge of chemistry, assisted by the mechanical and electrical engineer designs the plant for the conversion of the ore into metal, an operation which the metallurgist controls. The metal and its various alloys are then fashioned into various types of mechanised units, weapons, receptacles for containing high explosives and so on. The fuel supplying the motive power to vehicles may be either natural or synthetic; if the former the geologist has been responsible for indicating the source of the raw material and the chemist for refining it; if the latter, the chemist has been solely responsible, the equipment being designed and constructed by the engineer. The many scientific instruments required in war are based on knowledge and research by the physicists, and their contribution is no mean one. Thus from this scanty and hurried survey, it is evident that to laud one science to the detriment of another is not only foolish but stupid.

In other spheres we find scientists such as the botanist, together with the agriculturist and entomologist who also assist in the war effort by ensuring that all the necessary measures are taken to produce the bountiful harvests which are necessary to make the country as self-supporting as possible. When the harvest is garnered, the entomologist is again called upon to protect the grain from the ravages of insect pests and rodents.

It is not necessary to enlarge further on this topic, suffice it to say, that on each citizen there rests the responsibility of giving of his best in whatever position he may be placed, whether in combatant or non-combatant service, but there exists as I have endeavoured to show, no justification in lauding the contribution or sacrifice of any section as greater than that of any other.

Since the war of 1914-1918, we have been aware of the frightfully devastating effects of modern weapons of war, but it is safe to say that outside the realms of the imagination of a writer of fiction the possibility of the sheer lust, brutality and treachery of such a war, as that being waged at present with total disregard to humanitarian principles, had not been realised. The beauty and joy of human life has been ground into the dust so that a madman's ambition for world domination should be satisfied. There can be no doubt, however, that we shall rise from the depths to a newer and better world, for it is impossible to imagine that the achievements of moral degeneracy which have been so conspicuous in the present conflict should triumph over the manifold benefits of civilization. When the day dawns and there is peace again and the new and, let us hope, better world arises, what part is the scientist going to take in its disposition?

Since the beginning of the century, the position of the worker has improved considerably, social legislation has been enacted which has gone far to ensure for the toiler, who is the backbone of any democratic state, a reasonably fair deal and a moderate share of the many amenities of modern life. But much still remains to be done. The enormous scope of that branch of investigation which has become known as social science must be further extended and previous haphazard methods improved upon. In this regard an urgent call goes out to every citizen and particularly to the scientist who, with his trained and dispassionate mind, could take a very prominent part in the systematic examination and elucidation of the problems which present major difficulties to the ordinary citizen.

To a very great extent men of science in the past have stood aloof from the intimate questions of every-day life, but within recent years it has become more and more recognised that these matter-of-fact questions call for something more than casual inquiry. A lead to scientists in this direction has been given by our sister associations in Great Britain and America and the time seems opportune for us, as an association, to view our work in relation to society in this country. In 1931, H. E. Armstrong, that veteran warrior of science said:—

"In future the scientific worker to be worthy of the name must justify himself through social service in the first instance."

It is generally admitted that scientists have ignored, to a great extent, their obligations for the consequences resulting from the application of their discoveries in social and industrial life. In fact it has almost become a truism to say that social and economic problems are caused by the application of new ideas emanating from scientific circles. Overproduction and unemployment, and the evils they are fraught with, are problems resulting from these applications. A satisfactory solution of these vexed questions requires the attention and study of the best type of understanding. The comparatively recent establishment of an independent Department of Social Welfare in the Union, embracing within its scope such subjects as Child Welfare, Invalidity Welfare, Sub-economic Housing, Juvenile Delinquency, Settlements and Work Colonies, and etc., is a sign of recognition by the Government of the necessity for close and intensive study of the many and complex problems which come within the ambit of social services, and for the formulation of a definite policy of co-ordination and correlation of these services. Certain of the South African Municipalities have also established Departments of Social Welfare and in this way, within the area of their jurisdiction, they amplify the work of the Government Departments. It is interesting to note that many of the South African Universities now grant degrees in social science, the curriculum embracing a comprehensive training in subjects pertaining to this new but important branch of social work.

For many years the beneficence of science and its importance in our modern civilization was a frequent and striking text for presidential and other addresses. It was comparatively easy to give many apt illustrations of the application of scientific discoveries to industry and their prominent features were duly stressed and emphasised. Though mechanisation in industry had resulted in the displacement of manual labour, this labour was quickly and easily absorbed when these discoveries were put to a practical use and greater new industries were created. The same problem had been faced and the solution found when the industrial revolution took place a century ago and the agricultural worker became an industrial worker. In some cases the displacement was all to the good, for some types of manual work made excessive demands on the health and energy of the workers. In the newer industries, such as the automobile, electrical and chemical, the demands for labour are very great and as they continue to expand they will require more and more workers. But because such applications of science bring in their train problems of a social nature, which apparently are insoluble, this is no reason why scientists and their works should be condemned, and that abstention from scientific research for a period should be suggested, as has been the case in circles which are regarded as influential though obviously not very intellectual. Further, perverted use of the bounty of science cannot be advanced as a reason why the pursuit of science should be compulsorily stopped. Such proposals are futile. Notwithstanding all that has been said to the contrary the scientist can shoulder no more responsibility than any other citizen for the use to which his discoveries have been put.

It is customary, prior to the establishment of an industry in any particular district to examine the many factors which may have a bearing on its possible success. These considerations include, accessibility of the raw materials, proximity of cheap power, railway facilities, availability of labour and many more matters which more or less influence the final decision. In the same way, it might be possible before the introduction of any industrial process, depending on the application of a new scientfiic discovery, to make a complete survey of all the possible directions in which its introduction might react on the general public to its detriment. Such an examination might reveal that it would displace from some other well established industry a large number of workers who would become redundant and that a period of time would probably elapse before these employees could be absorbed in other directions. If this should be the case then the introduction should be allowed only under permissive conditions, for example a restricted output over specified intervals to enable the displaced workers to find other suitable employment. It may be urged that such a proposal might handicap and restrict progress. This, in some circumstances, might be the case but my chief concern is that the possible social implications of any new venture should not be lost sight of and, should they arise, endeavours should be made by intelligent anticipation to meet them. The services of the scientist in this connection would be invaluable.

It is true that always throughout the ages there has been a close affinity between science and war. Governments have spent large sums of money in research in connection with the adaptation of scientific discoveries to this end. The most industrialised countries are better able to wage war successfully than those not so well equipped and the conversion of industry from peace to wartime conditions is a matter, which though dependent to some extent on the character of the industry and consequently on the degree of alteration required is not so great as when these facilities are not available. Nevertheless there may be a lag in speeding up to meet the new conditions. This aspect of the adaptation of science to war has been discussed at length by others and need not be stressed further. It has only been mentioned to refute the imputation of the responsibility of scientists for the baneful use of their discoveries.

The neglect of Governments, public bodies and the like, to make use of the knowledge and abilities of men of science in administrative positions is a subject which has received a certain amount of attention in the scientific press. In the scientific age we live in there are few problems, if any, which come before administrators which do not involve technical and scientific factors. It is a sign of the times that there is an increasing tendency to fill the higher administrative posts in industry by men trained in science. Too frequently in the past, such posts have been the perquisite of those who have followed a legal, commercial or financial career. It can be argued effectively that as science has taken its place in the every day life of the people, the scientist, therefore must be responsible for the proper administration of the great benefits it has conferred on society.

The training of the scientific worker is based on service to the truth and this involves the application of scientific methods in an endeavour to assess, in their proper order, the value of the many factors bearing on the subject under enquiry. Too often in the past action has been based on either guesswork or preconceived opinions without full investigation to ascertain the true position. In an exact science it is possible from general knowledge to predict with great accuracy the exact course a specific reaction may take provided certain conditions are fulfilled and to indicate the products of the reaction. In sciences which do not come within this category, it is essential that all the facts and conditions on which action is proposed to be taken should be known, and their relative value or influence assessed as far as possible before the process is put into motion. The scientist with his specialised training is therefore in an advantageous position to conduct such an enquiry and when completed to suggest a course of action to be undertaken with every hope of success, the possibilities and probabilities of any repercussions of the action contemplated having been duly determined. Many instances can be called to mind readily when legislation has been enacted with insufficient knowledge of its implications and has resulted in producing chaotic conditions. Especially has this been the case in South Africa, particularly in connection with economic problems (about which I propose saying a word or two later). There is a vast field for the application of scientific methods in sociology, economics, distribution and finance and there has been some recognition, even if small, for the claim of the scientific expert to have a say, as well as the financial and administrative expert, in the formulation of policy. As the ability and skill of the scientist in applying his specialised knowledge to the many problems which confront society becomes more recognised his assistance and help will be eagerly sought and welcomed more and more. In my opinion, the sphere of activity which I have indicated is one where the scientist will find a wonderful opportunity for service, as well as gratification, in helping in some measure to find solutions for the difficulties which the perhaps too rapid advance of science have produced. There should be no delay by scientists in accepting and meeting this challenge.

The antagonism to the scientist as an administrator, which is met with in official circles, can only be removed by his own efforts. The many who hold the dictum that the necessary qualities of leadership are more likely to be developed by humanitarian studies than by study of the natural and mechanical sciences will find that their theories are incorrect. There is an inherent tidiness of mind in the votaries of science which should be of great value in organization. While it is true that in the past followers of science have taken little or no part in public affairs this does not connote, as I have pointed out, that they lack the necessary ability to do so or that the training they have undergone does not fit them from exercising to the fullest extent the functions of the ordinary citizen. There is a reluctance by scientists, admittedly incomprehensible, to meddle in mundane affairs. Nevertheless, it is quite common to find scientific men bewailing their treatment at the hands of Governments, public bodies and others and hoping against hope that someone will take up the cudgels on their behalf. Employers are reluctant to take any action which would have an adverse effect on their profits, unless compelled to do so, and the lack of an organisation to make effective representations on behalf of scientific workers militates against any satisfactory improvement in their status. In their own interests men of science, who have no sectional representation should band themselves together in an association on the lines of the British and American Associations of Scientific Workers. Such an organisation would be able to act for its members in the same way as is done by the British Medical Association and similar institutions. Trades Unions have done very valuable work in protecting the interests of their members and I personally see no lowering in the scientific status of professional men in becoming Trade Unionists in defence of their rights and privileges. I admit that to advocate such a step savours of heresy but "other times, other manners." This is my considered opinion derived from intimate experience of the functioning of professional organisations over a long period.

The various departments of State called upon to deal with scientific and technical matters are adequately staffed by professional men of high scientific standing, and they exercise their duties and responsibilities in a manner which can only command respect. In some cases, however, they do lack the industrial background which is to be obtained mainly by undergoing the rough and tumble of the factory and the field. In other words they are possibly too academic. Further, under the system of legislation which has grown up, facetiously known as "Government by regulation" which permits the Minister, under an enabling Act, to promulgate regulations for specific purposes, it is not uncommon in technical matters to find strong evidence of requirements which tend to curb trade and at the best are only an annoyance. A wider knowledge of industrial affairs would lead to better understanding and to improved departmental control.

Another unfortunate system, which cannot lead to the highest efficiency, is the frequent appointment of Government Officials and others occupying high administrative posts to dual positions carrying with them a second emolument. It requires little thought to indicate the impossibility of the incumbent filling two or more positions without sacrificing one or the other. This symptom of nepotism in State Departments is to be censured.

In the field of economics, where control boards run riot, an acquaintance by the members with commercial matters should prove most useful. On this subject of control boards and their functioning there appear to be two schools of thought in the Union, one embracing the theoretical economists who are engaged essentially in teaching and the other the practical economists who are mostly employed in the Department of Agriculture. On very few matters concerned with economics are they in agreement. Perhaps this is because the departmental officers promulgate the many regulations governing the functions of the Control Boards which are responsible for controlling and regulating the price, distribution and other factors relating to essential foodstuffs for which purpose they have been formed. (In fairness to these officers it is suggested that they may have to sink their personal feelings in the matter and formulate the regulations in accordance with the predilections of higher officials who have adumbrated the policy.) On the other hand, the theoretical economists have no responsibility and can await with indifference the results of the measures suggested by their more practical brethren under the Marketing Act "to provide for the orderly regulation of the production and the marketing of agricultural products by regulatory boards, etc." It does appear that the principal result of their efforts is to increase the cost of living and to place necessities of life beyond the reach of natives and the very poor. It is with much trepidation that I venture to express my views on this much disputed question and I only do so because I feel that it is a fruitful ground for some of our members to make a thorough scientific and therefore orderly examination of the results of apparently harmful legislation. This national problem of the satisfactory marketing of agricultural produce is largely bound up with the problem of malnutrition to which the Secretary for Public Health refers in his recent report, (1940). He says, *inter alia* . . . " surveys and an accumulation of clinical evidence from various parts of the country leave no doubt as to the seriousness of the position existing among non-Europeans and even among sections of the European population of South Africa." This complexity of the problem encouraged the Government to set up a National Nutrition Council in the Union, and the first meeting of this Council, which embraces medical and health officers, agriculturists, biochemists and sociologists was held in June last year. The work is to be carried on by four Committees entrusted with different responsibilities. The Universities of Witwatersrand and Cape Town, together with the South African Institute for Medical Research are carrying out investigations into the dietetic, clinical, sociological and economic aspects of malnutrition. Unfortunately the high hopes which were behind the formation of this body have not been realised. In the past twelve months apart from one committee, namely the War Emergency Committee, which is concerned with the health and feeding of the troops, no meetings of the main body or the subsidiary committees have been held. Recently attention to this failure to take action in regard to malnutrition in the Union was directed by the resignation of Dr. F. W. B. Osborn from the Research Committee of the Council. He stated that, while agreeing that more research was necessary, sufficient information was available to enable a start to be made to remedy matters. Dr. Osborn further pointed out that the personnel of the National Committee did not include " a single person who has made a close and detailed study of human nutrition."

One had hoped that the formation of the National Committee would have resulted in a comprehensive examination of the whole subject within the terms of reference, particularly from the economic aspect with regard to legislation affecting the marketing of agricultural products. It may be, however, that the resignation of Dr. Osborn (by drawing attention to the dilatoriness of the Council) may galvanise it into action, if this is possible!

As you are aware, the problem of malnutrition has given considerable thought to workers in this branch of science in Great Britain and elsewhere for many years. The magnitude of the problem can be realised from Sir John Orr's statement in 1935, that there were some 20 million people (more than 40% of the population of Great Britain) who largely owing to poverty, did not enjoy a diet which according to the modern science of nutrition was completely adequate for health, so that diseases due to malnutrition were still rife. Sir John Orr suggested that the marketing boards should act as public utility companies, controlling slaughter houses, bacon factories, milk depots, etc., buying from the farmer and selling to the distributing trade, thus making the staple foodstuffs available to the poorest classes at a specially low price. The deficiency in money received from the consumer would be bridged by a direct State subsidy to the farmer. The ultimate effect of the subsidy would be to reduce State expenditure on Public Health and Social Services.

It has been said, and the evidence for the statement seems reasonably conclusive, that in South Africa there has been no defined policy in the legislation on the subject of marketing agricultural products which has resulted in a "hotch-potch" of measures devised and introduced to meet apparent sudden emergencies This seems to be confirmed by the recent appointment of a Commission of Enquiry into the wheat industry, charged with an investigation concerning the economic position of that industry, with special reference to costs of production of wheat, milled wheaten products and bread, the system of farming practised in the main wheat-growing areas and the suitability or otherwise of those areas for the growing of wheat; the adequacy or otherwise of the protection accorded the wheat industry, and the advantages and disadvantages of the present protection policy. As Mr. J. J. A. van Rensburg said in the course of discussion at the symposium at the East London session, "Another problem, another commission. Far be it from me to criticise commissions. There is, indeed nothing to be said against them, if they base their findings on facts rather than on opinions."

Relative to the maize industry it would appear that difficulties have also overtaken the Control Board and a new scheme, which has been put forward for the sale of mealies has met with a great deal of criticism. Many of the problems which have been encountered seem similar to those confronting the Wheat Board of Control therefore the many adverse comments which have been made regarding the Marketing Act seem to have some justification in fact. Wheat costs the South African consumer an excess of 10/- per bag, due to the controlled price which is now 23/- per bag, while the price obtained for maize overseas barely represents the cost of production in South Africa and this is the staple food of the native section of the population as well as being an important component of the diet of the poorer classes of the European population. Within recent months the Maize Board purchased maize from growers in South Africa at 22s. 9d. per bag (480 lbs.) and sold the surplus amounting to approximately five and a half million bags, in London where the ruling price was round about 12s. This example of high finance was partly assisted by the South African Government, aiding the Maize Board by placing at its disposal a sum of £500,000, combined with the generosity of the British Government in purchasing all the maize available at a price between 16s. 3d. and 17s. 3d. per bag. The loss was met by a tax on every purchaser of maize in the Union of South Africa, in that 2s. 6d. was added to the price of each bag when used for human consumption. When used to fatten stock the tax was only 1s. per bag. This tax was actually levied on 6,000,000 bags sold in South Africa! This distinctly resembles the arithmetic of our childhood days, involving the papering of a room or the filling of a cistern with water from various sizes of pipes with the drain cock open.

The position regarding sugar merits a little special attention. Before the war sugar which was sold in the Union at 3½d. per lb. was sold in Great Britain at 2.3d. per lb. To-day, the price in South Africa is regulated by the National Supplies Control Board. The Government Grade Sugar which is of a light brown colour is sold at 2½d. per lb. and the sales of this commodity are rapidly increasing. However, refined sugar in Johannesburg, and within a limited area of the City, is sold at prices varying from 3 ounces for one penny to 11 ounces for threepence. Above 11 ounces and less than 12 lbs. it is sold at 4d. per lb. When sold loose the cost of 12 lbs. is 3s. 8d., while a 100 lb. pocket works out at 3.365d. per lb. It will be noted that for the smaller quantity, such as would be purchased by the very poor, the price is higher than is charged to the well-to-do who are able to buy larger quantities.

South Africa does not stand alone in this respect. It is generally admitted that in most other countries the economic planning developments have not only been haphazard but usually the measures were introduced on the representations of interested political groups.

While it may not be particularly instructive, it is perhaps interesting to enumerate the various control boards constituted under the Marketing Act, No. 26 of 1937:—

Dairy Industry (butter and cheese): Tobacco Industry: Mealie Industry: Wheat Industry: Dried Fruit: Deciduous Fruit: Chicory: Citrus: Livestock and Meat: Wool: Hides and Skins and Egg Levy. A truly formidable list to which must be added the sugar monopoly. The personnel of these control boards is drawn essentially from the producers and not the consumers. The chief result of their operations is that a higher internal price is charged to the South African consumer for these specified agricultural products, and the excess which is exported is sold overseas at a price below the cost of South African production. This procedure is technically termed stabilizing! It has been said by Richards that the efforts of our control boards result in South Africa enjoying the dearest wheaten bread, the most expensive sugar and the most costly butter of almost any civilized agricultural country in the world. If this statement is true, it is surely the most damning indictment which could be brought against our marketing policy and from the national point of view it therefore must be an extremely short-sighted one.

Let us consider some of the results of the Marketing Act. It is on record that Professor C. S. Richards calculated in 1933 that the control of agriculture by Government nominated boards or by regulation cost the country £7,473,000 and he stated that this expenditure had offered no permanent solution of the agricultural problem. At the same time he drew attention to the fact that in 1935, 9¼ million pounds of butter, equal to 40% of the creamery manufacture for the previous year, had to be exported at a loss of about 8d. on each pound.

There is general agreement that an increase of the per capita consumption of dairy products would, in every way, benefit the health of the European and non-European population of South Africa. A laudable attempt in this direction has been made by means of a State-aided Milk and Butter scheme introduced in 1935, which diverts to inland consumption as much as possible of the surplus dairy produce normally exported overseas. In this way a free supply of milk or cheese is made available to children and butter is supplied, at considerably reduced prices, varying from 6d. to 8d. per lb., to charitable institutions and necessitous families. It does seem that the State could go further in this direction and divert other agricultural products, either free or at reduced prices, for the nourishment of those who are at or below the bread-line. It is surely not beyond the wit of man to devise a scheme whereby that part of our population whether European or non-European, which lives under a perpetual dread of starvation could be ensured ample satisfactory food supplies, and not to send overseas to sell at prices below the cost of production foods essential for the well-being of our own people. To build up a strong, healthy and virile nation is one of the essential functions of a Government and the responsibility cannot be shirked.

The improvement in agricultural methods through the application of scientific knowledge undoubtedly has resulted in the past in increased production in many countries, while the economic barriers which have been erected by politicians may be considered to be the cause of starvation in a plentiful world. This maladjustment must be righted and if those who may be considered responsible for this condition in the country cannot remedy it they must be willing to give way to others who can. If in times of war money can be spent at the prodigal rate which modern warfare demands then in times of peace a war against malnutrition, inspired by the highest motives, must not be stinted for want of money. Parliaments which should represent a cross section of the varied interests and vocations of the peoples of a country are unfortunately too often composed of people representing vested interests, therefore any proposed legislation which might encroach on these interests has very little chance of success. Public opinion is however a great force in the world, and there are signs which indicate that when the present conflict is over there will be a more clamant demand for recognition of the rights of the people, so that measures should be taken now which will ensure an improvement in the lot of those who are in want.

In the change over from war conditions to those of peace great economic difficulties will be experienced. It is certain that many problems will have to be faced in the future, and already preliminary steps are being taken in an endeavour to prevent any serious upheaval in readjustments after the war. Not only will employment have to be found for the men who will be demobilised, but even the tempo of production in industry, particularly those industries engaged in the manufacture of armaments, will be slowed down and for these redundant workers provision will have to be made as well. These post war problems must be tackled with speed and imagination otherwise chaos in all branches of the life of the Union will ensue. It may be that either individually or collectively our Association can assist in helping those in authority to arrive at satisfactory solutions of some of the difficulties which will have to be faced and in this way widen its sphere of influence and obtain additional stimulus from such participation. In a word, we as scientific workers have to recognise that science is a part of human life, not something separate and distinct. Instead of being content, within the Association, with practising a narrow ideal and an exclusive devotion to experimental study, let us broaden our horizon and discuss in a constructive fashion those problems which impinge on our everyday life as citizens and for which we cannot rid ourselves of at least a measure of responsibility.

Without waiting to be consulted let us take the initiative and review among ourselves those broader questions in which science touches the interests and well-being of mankind as a whole. A start in this direction has already been made in connection with the excellent symposia arranged at the Maritzburg and East London meetings, when experts in their particular sciences discussed from this standpoint respectively the need for the conservation of national and human resources in South Africa. An enlargement of interest in this direction would infuse into the Association a quickening which would lend emphasis to the advancement of science in South Africa.

Let us be up and doing.

In my address I have given expression to the faith that is in me. To summarize, I believe that every able-bodied man and every woman, after a reasonable amount of work and leisure is entitled to go to bed in comfort with his or her appetite satisfied. The care of children and the aged must be the special responsibility of the community. As a recent writer summed it up—the elemental securities—bread, work and leisure for the commonfolk everywhere.

It is generally admitted to-day that the whole basis for our future happiness and peace depends on a sound economic foundation—the solving of the problem of poverty in a world of plenty. This problem cannot be approached in a parochial manner: it is international in character and a solution which would possibly meet our needs and requirements in South Africa might conceivably be disastrous to our neighbours. It requires much thought and consideration to arrive at a practical result and those statesmen who will be responsible for its solution are entitled to ask and to receive our sympathy and co-operation.

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PROBLEMS OF IRRIGATION DEVELOPMENT IN SOUTH AFRICA

BY

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Presidential Address to Section A, delivered 30th June, 1941.

South Africa is a country in the relatively early stages of its career in the field of irrigation and is consequently in a position to profit by the experience of other countries which have reached a greater degree of maturity in this branch of human enterprise. Since the major portion of my professional work has been concerned with irrigation and my studies of this subject have extended to a number of countries, I propose to discuss problems of irrigation development in some of these countries, to deal with certain principles enunciated by them for guidance, and to consider these principles in relation to relevant factors affecting irrigation development in the Union. The countries chosen for special reference are India, the United States of America and Australia—all of which are forged upon the continental scale of South Africa. The former is one of the earliest homes of irrigation and possesses side by side with extremely primitive systems, some of the most modern and stupendous in the world. The latter are relatively recent entrants into the field but to-day possess irrigation schemes of considerable magnitude which furnish examples of modern progress and endeavour in many branches of the science of irrigation.

Physical Conditions.

In drawing conclusions as to the extent to which the experience of other countries may be applied to South Africa, it is necessary in the first instance, to form a reasonably clear conception of the similarity or dissimilarity of physical conditions in the countries concerned. The more important factors are those which control rainfall and climate, and those which determine or have determined topography. The rainfall in any region of the world is determined primarily by its location in relation to the planetary wind systems of the world, the elevation of its land mass and its position relative to the great oceans of the world. The planetary winds blow from the zones of high atmospheric pressure to those of low atmospheric pressure and, since the positions of these zones are in the main determined by the rhythmic motion of the sun which gives rise to the seasons and by the distribution of the land masses and oceans of the world, they cannot be considered to be subject to control by the puny efforts of man. Closely related to rainfall and topography is climate—a feature which is usually faithfully reflected in the vegetation of the region concerned. In so far as South Africa is concerned studies of its vegetation show beyond doubt that the major portion of the Union has for centuries been an area of relatively low rainfall. Since the factors determining rainfall and climatic conditions are reasonably well known, and since these demonstrate that rainfall is settled by conditions beyond the control of man, my approach to the practical problem of irrigation will be concerned with showing how best to use the rainfall that actually exists. These observations indicate my opposition to indulgence in speculative theories as to how rainfall may be increased or modified, yet while they tend to absolve man from the charge that he has been responsible for existing rainfall conditions in South Africa, they are in no way intended to mitigate the extreme censure he deserves for his culpability in changing the effects of rainfall by destroying surface vegetation and generally contributing to the ruining of the surface of the land.

Hydrographic Conditions.

The physical conditions most intimately associated with irrigation in the four countries under review may be briefly summarised as follows.

In the arid regions, that is those deficient in total rainfall, the distribution of rainfall is seasonal even though spasmodic in its occurrence, the conditions of rainfall show a considerable degree of similarity, and in general the rainfall is a summer rainfall. While rainfall conditions exert a material influence upon the flow of rivers, topographical factors also provide an important control and, as topographical conditions are divergent in type ,there is a marked difference in the hydrographic conditions in the various regions under discussion. In Northern India snow storage, particularly in the Himalayas, is a dominant factor; it gives rise to steady flow in the rivers so that, even at their lowest ebb, they are of considerable magnitude. In the United States of America snow storage has a marked influence upon the maintenance of steady flow in its rivers but irregularity in river flow is nevertheless pronounced. In both Australia and South Africa snow storage is for all practical purposes non-existent, so that the flow of their rivers is erratic and, in the case of practically all streams, varies from minute rivulets to temporary raging torrents. The general prevalence of forest-covered catchments in Australia however, tends to even out the flow of its rivers but, on the other hand, the violent fluctuations in intensity of rainfall tend to have a contrary effect.

The effect of the conditions outlined above upon the yield or run-off that can be expected from catchments of the same size when subjected to the same total precipitation would be to produce a high yield in Northern India, a moderate yield in the United States of America, and a low and erratic yield in both Australia and South Africa. Now the actual precipitation is greatest in Northern India and that in the United States of America is usually greater than in both Australia and South Africa; consequently, from the point of view of water supply, Northern India has phenomenal resources, the United States of America material resources, while Australian and South African water resources must be judged to be very moderate. As the total water resources of a catchment and regularity of suply are dominant factors in the determination of the storage capacity of reservoirs required to conserve or regulate the flow of any stream, the following conditions obtain. In Northern India huge areas of land can be assured of a dependable water supply without any cost being incurred for conservation, in America storage is usually essential but only upon a moderate scale in relation to the area of land irrigated, while in both Australia and South Africa irrigation requirements involve the provision of a considerable amount of storage to serve a relatively small area of land. As an example of the inferior position of South Africa in respect of water resources, the following statement is illuminating. Observations show that the normal minimum flow of the river Indus at the site of the Sukkur Barrage (above which point various tributaries of the Indus have had diverted from them enough water for the irrigation of approximately ten million acres of land), is five times the steady flow which could be obtained from the Vaal

River if all its waters were conserved and passed down as a uniform stream. Also the latter figure is only one-sixteenth of the average flow through the Aswan Barrage on the Nile in what is termed a very low year.

Suitability and availability of land for irrigation form important items in schemes of irrigation and the position in this respect may be fairly represented as follows. In Northern India the huge rivers of the Punjab traverse immense alluvial plains which merely await the application of water and intelligent human endeavour for their conversion into fertile lands; in the United States of America the rivers are usually of considerable magnitude and generally associated with open valleys and plains containing fertile soil. In Australia which consists generally of low lying land, slow-flowing rivers pass through wide alluvial plains in which extensive rather than intensive irrigation development is taking place; in South Africa steeply graded rivers flow from the interior plateau to the sea and the fertile land is generally restricted to attenuated valleys of relatively small area.

This brief outline of physical conditions is intended to show how the stage is set for irrigation development in these four countries. It has been presented in order to reveal the background to be kept in mind in any discussion relating to the extent to which human factors may influence irrigation development and must be taken to constitute an essential preliminary to the ensuing discussion of irrigation policy.

Irrigation Policy in India.

In British India most of the land involved in irrigation enterprise is held by the Crown, the irrigation schemes are constructed from Government funds and settlement invariably takes place at a rapid rate. The design, construction, operation and maintenance, settlement and collection of rates is the function of the Irrigation Department so that the whole undertaking is from the date of its inception under one management which is well able to assess the relative importance of the various factors influencing the project as a whole. Water is supplied according to a fixed time schedule —the amount supplied depending upon the crop actually irrigated. The water rate is not based upon the cost of operation and maintenance but upon the crop irrigated, and, while in no respects a burden upon the irrigator is usually sufficient to result in a handsome profit which is paid into the general revenue of the country. The Indian irrigator seldom fails to pay his irrigation rates and payment rather than default has become a habit.

The underlying principle controlling the financing of Indian irrigation projects is that the scheme should at least pay the interest on the sum invested. A scheme based upon this conception is known as a " Productive Scheme." However in certain areas where the population is frequently the victim of famine the following is the basis of finance. If the difference between the estimated return from the scheme and the market rate of interest on the money necessary for its construction is less than the mean annual sum spent by the Government in famine relief in the particular area, the project may be sanctioned and built. In this case it is known as a " Protective Scheme."

Irrigation Policy in the United States of America.

Irrigation schemes financed either by Federal, State or private enterprise, have found no easy path to progress and only a few of these can be considered to have reached any degree of financial success. In the case of projects financed by the Federal Government the bulk of the land is owned by the Government and the policy of settlement accords to the following principle. The amount of land which a settler may take up is limited to that which, in the opinion of the Minister in charge of the Bureau of Reclamation, is sufficient for him to develop adequately and to allow him to bring up his family with reasonable comfort. Until 1924 the annual irrigation rate consisted of a redemption rate calculated to repay the whole capital charge in twenty years without interest plus a rate based upon the annual cost of operation and maintenance of the scheme, but after that date the amount assessed in any year on account of repayment of the capital cost of the scheme is a fixed proportion of the annual gross value of the crop produced. The irrigator's liability on account of capital costs is limited to the fraction of the total cost of the project which his area of irrigable land bears to the total area of irrigable land embraced within the scheme. The basis of supply of water accords to the following principle. The irrigation rate entitles the irrigator to a definite quantity of water per acre but any excess is charged for separately. The effect of this procedure is to place a premium upon the efficient use of water.

The Bureau of Reclamation assumes control of operation and maintenance of the scheme for a number of years after its completion until such time as irrigators have obtained a clear insight into this phase of irrigation enterprise; thereafter control of the scheme is vested in the irrigators who take full responsibility for its administration including liability for repayment of capital charges to the Government. In the majority of cases the management is placed in the hands of a chief engineer or project manager appointed by and responsible to a Water User's Association elected by the irrigators.

Irrigation Policy in Australia.

It is a difficult matter to generalise upon the subject of irrigation policy in Australia since the various Federal States have definite individual rights which are reflected in their respective attitudes to the problem of irrigation. Nevertheless in spite of minor differences, their policies have much in common so that a general statement relating to one state may be considered as reasonably applicable to all. The state chosen here as representative of Australia is New South Wales.

The control of irrigation and water supply in New South Wales is vested in the State Water Conservation and Irrigation Commission which is composed of the Minister of Agriculture and two commissioners.

The Commission administers the Water Act which empowers the State to construct or acquire works to provide supplies of water for irrigation, stock and rural domestic supplies. It takes full responsibility for the construction. operation and administration of national works of water supply and is responsible for the settlement of the areas concerned. Provision is made for the formation of Irrigation Trusts for water supply, irrigation, drainage and development of artesian water, but these are all subject to the control of the Commission. The capital cost of works constructed by the Commission is repaid with interest by the occupiers benefited by the works in instalments spread over a number of years. The conditions of purchase of land or the leasing of land include the stipulation that improvements of definite value be effected within a time fixed by the Commission. In order to assist it in its activities connected with development and settlement the Commission is empowered to construct streets and provide town water supply, sanitary and other services. It undertakes the initial financing of factories and owns butter factories, bacon factories and canneries, but these activities have been based upon the assumption that the factories will later be taken over by co-operative companies in which the shareholders are the suppliers. The Commission is empowered to exercise control over the sub-division of land by private persons who desire to construct irrigation works and then sell small areas as irrigation blocks.

Irrigation Policy in South Africa.

In the Union the inauguration of an irrigation scheme proceeds along the following lines. Subsequent to certain formalities specified in the Irrigation Act, owners of riparian land embraced within the project elect an Irrigation Board. This board borrows money from the Government and pledges the land to be irrigated as security for the loan—contrary to American practice this liability is joint and several. During the period of construction the Irrigation Department exercises general control but, upon its completion, the scheme is handed over to the Irrigation Board which thereupon assumes responsibility for levying the irrigation rate, for operation and maintenance and for the equitable distribution of water. The irrigation rate levied must be sufficient to repay the fixed charges due on account of interest and redemption of the Government loan and also be adequate to meet the annual cost of operation and maintenance. The rate per morgen is determined on a pro rata basis—the amount due by each land-owner being proportional to the area of scheduled land he possesses. The burden of repayment is eased in the earlier years by the application of the following device. The due date for the collection of the first instalment in repayment of interest and redemption of the Government loan is postponed for a few years after completion of the works, but interest charges accruing during this period are added to the capital cost of the scheme.

Irrigation Law.

A comparison of the irrigation laws of India, the United States of America, Australia and South Africa, can be made only in briefest outline which should nevertheless be sufficient to indicate how wide is the divergence of view with which this matter is approached. In modern India irrigation law has developed in a happy environment. The men responsible for it conceived it as an instrument for implementing a policy whose purpose was to enable those responsible for irrigation development to effect the most economical and beneficial use of the essential elements—land and water. It avoids the disastrous effects of giving protection to speculative holders of land and is essentially designed to serve the widest national interests.

In the United States of America each state has its own irrigation law so that this country offers wide scope for the study of this subject. The earlier irrigation laws were based upon the riparian law—a law which experience has generally shown to be ill-adapted to the conditions that exist in arid regions. As a result most of the states in the irrigated west have discarded the riparian law in favour of the " law of prior appropriation." Briefly the latter gives water rights only to people who are actually developing land and are using water beneficially—the various rights to water being given in priority of enterprise but limited to what can be beneficially and economically used. A study of the water laws of successive American states reveals the following broad picture. In the humid east where irrigation is practically non-existent, the riparian law holds sway. In the central regions where the claims of irrigation have not become predominant, one State has adopted one law and another the other law. In the arid west where irrigation becomes the major thought of the agricultural population, the riparian law has generally been discarded and replaced by the law of prior appropriation. This example throws into relief the spheres of applicability of the riparian principle and the principle of prior appropriation and effectively illustrates the adaptation of law to specific needs and environment.

In New South Wales the State Water Conservation and Irrigation Commission controls the allocation of all water supplies. In terms of the Water Act of 1912 " the right to the control and use of all water in all rivers and lakes is vested in the Crown. No person is permitted to obstruct the flow, change the course of or divert water from any stream (including pumping) unless a license has first been obtained from the Commission (except for domestic use and the use of stock in an area not exceeding five acres)." The Act also provides for the control and licensing of artesian boreholes. Before a license is granted a public enquiry is held and upon favourable recommendation, a license is issued on payment by the applicant of a prescribed fee based upon the class and capacity of the works.

The irrigation law of South Africa is based upon the principle of riparian rights. The riparian law may roughly be defined as one which reserves rights to water to farms through which a river passes or upon whose boundary a river impinges. It excludes other farms which do not happen to be so situated. This principle which is derived from laws applicable to humid areas is a development of the old Roman law and was for centuries embodied in the irrigation laws of Italy but was discarded more than half a century ago because of the obstacles it imposed upon progress.

The practical application of the riparian law in South Africa has led to many difficulties and produced many somewhat nebulous rights. In the first place it has led to the division of the surface waters of the Union into two categories —" normal flow " and " surplus water." Normal flow may be approximately defined as the more or less steady flow which can be used for direct irrigation without the aid of storage, surplus water (flood water) as that portion of river flow which cannot support a permanent system of agriculture without the aid of conservation. As a result it becomes necessary first to divide the somewhat erratic and indefinite flow of the South African river into these categories and then to endeavour to allocate these in an equitable manner among riparian farms. As normal flow is not solely a physical feature of a stream but is related to the irrigation potentialities of the land riparian to it, the determination of normal flow often presents a complex problem—particularly in cases when hydrographic records are meagre and where the irrigation potentialities of riparian farms are ill-defined or problematical. Assuming however that the normal flow of a stream has been defined, the only means of dividing it among riparian farms appears to be by the application of the principle of proportionality—a system of division which is often difficult and expensive to carry out in practice and one which frequently leads to the physical division of water into such small units as to make the division economically unsound.

The Irrigation Act of 1912 gave a privileged position to upper riparian owners since they were legally entitled to divert for their own use water which lower owners might be using to irrigate land in the development of which they or their forefathers had spent money, time and energy. The privileged position of the upper riparian owner was such that there was little security for lower riparian owners who had constructed or wished to construct conservation works for the storage of "surplus water" and the consequent lack of security provided a serious bar to enterprise. The position was to a great extent corrected by the introduction in 1922 of the so-called "protection clauses" of the Irrigation Act which had as their aim the protection of established storage works, and were designed to secure such works against the possibility of upper riparian owners at a later date indiscriminately constructing storage works and thus diverting the supplies of water essential to the existence of previously constructed schemes. The effect of the protection clauses has been to place the allocation of flood or surplus water on a reasonably sound basis since, prior to allocation, a tolerably comprehensive study and assessment of the potentialities of the river system is required and owners of land are forced to declare their plans of future development. Upon the basis of these declarations and a study of the actual potentialities of the areas concerned an allocation of surplus water is made by the Water Court, consequently rights to surplus water are reasonably definite.

The protection clauses embody much of the spirit of the law of prior appropriation and it is worthy of note that their introduction led to much opposition from persons who brought forward the spurious argument that they were inimical to the pioneer. A little reflection, however, will show that both their purpose and their effect is to protect the pioneer since they protect owners in priority of enterprise; the persons whom they do not protect are the speculative holders of water rights attached to riparian land. The protection clauses are now firmly embodied in the water law of the land and are to-day accepted as being fundamental to progress in irrigation development in the Union.

Possible Modifications of the Irrigation Law.

Water coming under the definition " normal flow " form only a small portion of the total water resources of the Union and as a considerable proportion of this has already been allocated, little can be gained by adopting any material modifications of the riparian principle with regard to normal flow. However in the case of " surplus water " which forms the major portion of the water resources of the Union, the riparian law continues to offer obstacles to progress, in spite of the fact that the protection clauses give some degree of security to storage schemes based upon the conservation of flood water. A specific objection to the riparian principle is that it is based upon a conception which fails to take adequate cognisance of physical factors which influence or control the design of irrigation schemes —some of which are set out below. In the case of relatively small storage schemes conditions are usually such that the land commanded is practically all riparian but where major schemes are concerned, topographical conditions are likely to dictate their salient features and the following major controls normally operate. Sites for either the storage or diversion of water are extremely limited and topography is such that the canal must take a course well away from the immediate precincts of the river. The effect of the first is irretrievably to settle the position at which a storage dam or diversion weir can be built, of the second to lead to the location of a canal that soon commands a considerable area of non-riparian land. In a scheme drawn up to deal with land which is irrigable only on account of the fortuitous circumstances of the riparian law, the physical conditions which make for compactness and economy usually have to be sacrificed with consequent increased costs of irrigation development and resultant interference with its real purpose —namely the most beneficial and economical use of the national resources of land and water.

The question of the relative merits of small and large irrigation schemes is one upon which no generalisation can be made except that it may be assumed that the soundest method of exploiting the resources of a large river is by means of major works—though the possibility always exists that conditions may be such as to permit the construction of a series of small schemes. In the latter case the bulk of the land would conform to the definition "riparian" and there would be no essential conflict between factors settled by physical conditions and those determined by human agency. In the case of irrigation development from the larger rivers of South Africa this harmony is not likely to exist, in which case national interests demand that irrigated land must not be confined to narrow strips of land along the river front but must be allowed to embrace a wide and comprehensive area. Since water is the really valuable commodity it is not a sound policy to develop water resources for use in conjunction with relatively inferior land merely because this land happens to accord to the arbitrary definition—riparian. As the application of the riparian principle to major schemes has interfered with the adoption of the most rational method of large scale development, the abandonment of the riparian principle in respect of "surplus water" represents a desirable departure from the point of view of the successful exploitation of the larger rivers of the Union. An outstanding example of the benefit of a broad outlook is found in the Punjab where, in the Triple Canal Scheme, the water resources of three great river systems were pooled and re-apportioned in such a manner as to effect maximum use of available land and water and so led to the development of one comprehensive unit embracing some ten million acres of irrigated land. It is not contended that anything approaching this is possible in South Africa but this example illustrates that, had India been hampered by restrictions associated with the riparian law, such a combination of essential resources would have been impossible and development upon sound lines would have been retarded or rendered impossible.

Conclusion.

South Africa has probably passed through the phase of taking for granted the immense irrigation possibilities which were tacitly assumed to exist in the opening days of the present century and is now disposed to assess its irrigation potentialities upon a study and analysis of hydrographic records. This has led to a reduction of claims to modest proportions and the presentation of a truer picture of the problems awaiting solution. In the opening pages of this address an endeavour was made to show the scene of irrigation in South Africa in the perspective set by other countries and, in later pages, to draw attention to the manner in which human agencies affect or modify the scene. In so far as a general summary is possible, it may be accepted that in the sphere of physical environment the controlling factor is the paucity of actual supplies of water which factor taken in conjunction with irregularity of supply makes necessary the provision of a large amount of storage in proportion to area irrigated. An immediate consequence is that losses by evaporation are high so that, even with conservation upon a generous scale, there is no possibility of ensuring that water conserved will be adequate to meet requirements during conditions of severe drought. For this reason there is a good case for adopting the apparently costly policy of deliberately selecting sites for dams at localities where deep reservoirs of relatively small surface area will result, so that for a given quantity of water stored the losses due to evaporation will be minimised; at the same time it is clear that in order to protect capital invested in the agricultural side of irrigation, the proportion of perennial crops to annual crops must be very carefully studied and regulated.

While admittedly South Africa suffers from the disadvantage that topographical conditions make the country a difficult one to irrigate, many of its troubles find their origin in human agencies. Chief among these is the fact that owners of large areas of land have neither the time nor the capital to develop all the land scheduled as irrigable, consequently rates for the whole scheduled area must be paid from the products of a portion of it. Unfortunately the owner who has no ready means of disposing of his surplus land, complicates the position by asking too high a price—forgetting that the land has still to bear its portion of the debit for capital cost of the scheme. A further factor is that the operation and maintenance of large schemes passes into the hands of Irrigation Boards at too early a stage with the result that this important phase of irrigation enterprise is frequently relegated to men with an insufficient knowledge of hydraulic engineering, consequently adequate supplies of water are often inequitably distributed and waste of water takes place.

Irrigation problems in the Union were subjected to thorough investigation in 1925 by the Irrigation Finance Commission whose report forms a valuable document dealing with irrigation conditions in the Union. In its report the Commission advocated the creation of a strong permanent executive Irrigation Commission with adequate powers to form a co-ordinated administration dealing with all phases of irrigation development. Actually only limited effect was given to its recommendations and, in place of an executive commission, the Government substituted an advisory commission. The reasons which led to the non-acceptance of this recommendation of the Commission are not clear, since in most countries in which irrigation has met with pronounced success the department responsible for irrigation is not limited in its activities to the construction of irrigation schemes but is responsible for their operation and maintenance and the inauguration and control of schemes of settlement.

Two countries which have met with outstanding success in the field of irrigation development are India and Egypt. In these the resources of water are enormous, fertile land is readily associated with rivers easily divertible for irrigation purposes, the population ready to take up the land is available on the spot and settlement takes place at a rapid rate. In the former the water laws permit the most beneficial use of the land and water resources and there is little scope for speculation in land or negligence in developing it; in the latter the source of supply is the Nile—the regulation of which and the distribution of whose waters is the basis of the country's activities. These two countries therefore have everything that makes for success in irrigation development—great water resources, fertile land easily irrigated, immense population available to develop the land and eminently satisfactory water laws. The environment in which irrigation has developed in the United States of America, Australia and South Africa has little in common with that of India and Egypt; on the other hand there is a general similarity in irrigation conditions in the first three countries. South Africa lags behind the United States of America and Australia in its policy of settlement, and still suffers from disabilities inherited from the older irrigation laws of the last century; its people have been slow to appreciate the relative smallness of the water resources and have adopted too static an attitude upon the question of water law. Much of the opposition to changes in the water laws of the Union has arisen from the belief of riparian owners that their projected schemes, many of which are of a fantastic nature, are capable of conversion into physical assets and that their vested interests in the riparian law have a good cash value. This encourages speculative holders to retain possession of land and so interferes with the activities of progressive men who are ready to go ahead with development. The riparian law was undoubtedly embodied in its present form in the Irrigation Act of 1912 because this act had to take account of rights which had matured under the old Roman-Dutch law which then dominated the position. This law took little account of the requirements of industry which was consequently left in a very inferior position in respect of rights to water. The necessity for making equitable provision for industry to obtain the supplies of water it will require if the great industrial development anticipated is to mature, should be a reminder to the people of the Union that they should approach the subject of water law with an open mind and display an attitude consistent with the spirit and requirements of modern democracy.

In dealing with any subject to-day the consciousness of the stress and uncertainty of the times is ever to the fore and likewise the obligation to plan for the days of peace. Various indications point to the fact that, in the immediate post-war phase, employment will be found for many in public undertakings involving large scale civil engineering works. Many may lightly assume that all that is required is to have an idea of what is to be done, to arrange the necessary finance for embarking upon an undertaking and so absorb a multitude of persons in employment. The actual position will be by no means so simple since major schemes of civil engineering development—be they in the fields of irrigation, railways, roads or public works—require long term investigation, planning and design before the stage is reached at which construction may proceed. In the circumstances it is desirable that, except for men required for services directly connected with the prosecution of the war, there should be a general diminution in non-military constructional activities and the services of as many civil engineers as possible should now be devoted to the surveying, planning and design of major schemes whose construction should be held in abeyance until they can be co-ordinated with efforts to provide employment immediately after the war. A further contingency that should be kept in mind is that, in releasing men from active service, adequate account must be taken of the necessity for the early release of men best qualified to carry out this preliminary work. If adequate regard is not paid to these factors there is the practical certainty that large numbers of men will be drafted to works at which the controlling authorities will not have had time to complete their designs nor arrange suitable programmes of work. In such circumstances they will be unable effectively to deal with the men arriving on the scene. Such a situation must be avoided at all costs and yet it is easy to drift into such a position if it is complacently assumed that large scale civil engineering schemes can be inaugurated without preliminary long-term investigation, planning and design.

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THE SOCIAL CHALLENGE TO THE CHEMIST WITH SPECIAL REFERENCE TO AGRICULTURE

BY

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Presidential address to Section B. Read 30th June, 1941.

Glancing through the presidential addresses of my thirty-eight predecessors in this office, to which your Council has appointed me, and for which honour I am deeply grateful, I have felt that the responsibility I have undertaken is no light one. The honours have in the past been fairly evenly distributed. Eleven former presidents of this section were agricultural chemists. Those from mining and metallurgical sources number twelve, while geography and geology have supplied thirteen and two fall outside these categories. It is now again agriculture's turn and, as this industry has been so much criticized and maligned in commercial, mining and professional circles of late years. I feel it incumbent on me to defend it, and attempt to make clear its importance and the necessity for keeping it flourishing in a world somewhat technologically unbalanced and economically warped.

In the plutocratic atmosphere of urban centres with colossal commercial establishments and flourishing industries, agriculture with its economic and social ailments is apt to be treated as a poor relation of little account. Hofmeyr told this Association in 1939 that because of our immensely rich gold mining industry, we had come to believe that the country as a whole is rich, with the result that there has been built up in South Africa a higher standard of living than the permanent resources of the country really warrant. This evil is apparently not peculiar to South Africa, for Knapp in 1933 concluded that the whole world was living beyond its means, which made the general state of affairs appear much more favourable than it was. He states that the total consumable average income per person in civilized countries for the previous ten years had not been more than

£33 per annum. The East London symposium also indicated that poverty was the main cause of our physical and moral ills.

Du Toit points out how much superior mining is to agriculture when it comes to revenue accruing to our government and suggests that agriculture must turn more to science for its rehabilitation. Agriculture has had plenty of assistance from science locally, what it needs more is science applied to social and economic ills on an international scale. This aspect will form the main theme of my address.

THE IMPORTANCE OF AGRICULTURE

In the murky air of urban areas it is difficult to see agriculture in its true perspective, which I think was properly given by President Garfield about 1880 when he said:

> "At the head of all the sciences and arts, at the head of civilization and progress stands—not militarism, the science that kills, not commerce, the art that accumulates wealth—but *Agriculture*, the mother of all industry and the maintainer of human life."

Mining he apparently thought unworthy of mention. A few facts about the importance of South African agriculture taken from the Secretary of Agriculture's report for 1939 will not be out of place at this stage. Some 700,000 of our white population live on 104,000 farms comprising about 100,000,000 morgen, with a valuation of at least £300,000,000. Our Division of Economics has also estimated that if the value of livestock, implements and equipment is added, then the amount invested in agriculture totals the huge sum of £457,000,000. The average annual value of the products of the land for the six years previous to 1939, including those consumed on the farms, was estimated to be £56,000,000. This is real wealth. Agriculture thus still plays the leading role in our national economy and for that reason the townsman should be more patient with the farmer and more sympathetic towards those measures which our government adopts to try and make the farmer pay his way in the face of stupendous economic and social difficulties. The city dweller should remember too, that agriculture gives a living to a far greater number of persons, both black and white, within our Union than any other industry. Knapp estimates that two-thirds of the world population are engaged in the cultivation of the soil. Sir Robert Greig at the combined meeting of the British and this Association in 1929 said:

> "But agricultural wealth, the capacity to produce every year the food and clothing, without which life ends, is—and always has been the one great permanent industry—the one which is the foundation of all national or indeed, world wealth."

He also quoted Lord Ernle as saying in the same year:

> "The question has already arisen, how far is it safe in the world's interest to allow the decline of Agriculture."

Some of you are no doubt wondering where the chemist comes in. Well, he does appear, but in a rather minor role and more as an observer and recorder than an actor. To-day, the benefits of chemistry to agriculture are not so apparent as they were thirty years ago. This subject I dealt with rather fully before this Association in 1936 when discussing "Agriculture and the Chemical Industry" and will thus say very little about it now. To-day the chemist is one of a team consisting of agronomists, botanists, geneticists, entomologists, economists, animal husbandry officers and veterinarians. This co-operation has benefitted agriculture considerably, even if the sciences are less prominent individually.

The chemist is justifiably proud of the part he has played in improving South Africa's soil fertility and increasing her crop yields, and in the case of maize changing her from an importer tc an exporter. This satisfaction soon vanishes when someone brings up the question of tariffs, bounties, subsidies, levies, maize boards and the lower price of Union maize abroad, as compared with its higher domestic cost. It may further be pointed out that cattle feeders have been able to purchase maize more cheaply than Transkeian natives for whom it is indeed the staff of life. The chemist may now feel somewhat depressed and deflated and wonder whether after all he has done such an excellent thing as he thought he had in increasing maize yields. He should, however, take comfort in the fact that Parish has pointed out, that unless the farmer can get 8 to 10 bags of maize per morgen, there is little or no profit in growing the crop. The chemist has enabled him to do this and more, and to reduce his production costs and carry on for years in a world wanting ever more bags of maize for its industrial products. An international economic conference called by the League of Nations in 1927, found that the farmer had to exchange 25% more of his produce for manufactured products as compared with 1914. It is undoubtedly more pleasant to tell of the wonderful benefits chemistry has brought mankind, but the chemist worth his salt must recognize that his science has been the cause of many social and economic changes and that for better or for worse he is in the flood along with the rest of mankind. We have stuck to our own peaceful rivulets and quiet backwaters too long, blissfully ignorant of how they have swollen the social and economic river of mankind and the destructive floods they have caused.

It is time the chemist went voyaging on the waters of the flood to which his kind has contributed so liberally. It will certainly be an adventure in which he will observe many striking sights as he goes careering through the economic cataracts and plunges past the dangerous rocks of social welfare. It is his duty to record truthfully what he can observe while he still has the chance, however unpleasant it may be and however incompetent he may feel for the task. This may be an example of the chemical fool rushing in where social and economic angels keep clear of the unholy flood by means of their wings. However, I take comfort in and extract an alibi from the words of the economist Knapp, who wrote:

> " After all, people have at once to begin to realise that our economic life is so complex that no one, including the greatest thinkers, the sharpest economists and the cleverest statesmen, can view it in its entirety. The reality is accordingly so overwhelming that it gives one a sense of anxiety, a fear that matters will go wrong."

It certainly does, and so, if at the end I have been unable to crystallise any worth-while ideas from the dark brew of figures, facts and opinions, which has been simmering so long, and leave you instead with an amorphous mess, you will know the reason why. Sarton says:

" Nothing is more difficult than to begin,"

but I have found the extraction process infinitely harder. Dr. Knapp has so converted me to his views on agricultural economics, that I shall quote frequently from his book " World Dislocation and World Recovery." For this thesis he received in 1933 the Humbert-Marie José prize on the decision of the committee of the International Agricultural Institute at Rome, as the best work among thirty-three competitors.

WHAT IS WRONG WITH AGRICULTURE?

I can hear a chorus of urban voices answering this question without hesitation: "The farmer is too lazy and inefficient and doesn't know his job. He wants some organisation and more mechanisation on his farm." On the contrary we know that many princes of commerce and successful professional men, who certainly should know something about organisation and efficiency, have found when they turned to farming, that it was a far more difficult calling than they had anticipated. They had not quite appreciated the difficulties an uncontrollable nature generates. As Furnas aptly put it:

> "A wolf on Wall Street is a pitiful shorn lamb if he steps into the cornfields with the hope of winning his sustenance . . . If he should embark on the venture he would probably find that 'playing the horses' is more certain of return."

Many men of means in South Africa would appreciate this viewpoint only too well.

There are admittedly, inefficient and lazy persons in every walk of life and that of farming is no exception. I hope, however, to show that the malady from which South African Agriculture is suffering, is not due chiefly to local shortcomings, but rather to a world-wide condition affecting agriculture as badly in other countries. Leppan in 1938 contributed the view that:

> "Haphazard production and maldistribution have caused an unmanageable surplus."

This may be true economically, but socially there is no surplus. Bernal tells us that four-fifths of the human race have less to eat than is compatible with health, let alone efficiency. Orr too, showed that half the population of Britain suffered from deficient feeding and that one-fifth of them were below minimal fitness. Fox worked out that for pre-war England, 7/- per person per week was required for a reasonably attractive diet of nutritional adequacy, whereas millions could spend only 4/- to 6/- per week. It seems obvious therefore that it is purchasing inability rather than surplus production that is to blame, although over-production in the economic sense does exist. The food is there in abundance, but man's unbalanced social and political relationships do not allow of its proper distribution to the underprivileged. You can feel Bernal's fervid condemnation of the present system when he writes:

> "War, in a period of potential plenty and ease for all, is sheer folly and cruelty . . . The greater part of the disease in the world to-day is due directly or indirectly to lack of food and good living conditions. All these are plainly remediable evils and no one can feel that science has been properly applied to human life until they are swept off the face of the earth."

Haylett suggests subsidising the consumer as is already done as regards dairy products for school children in South Africa. He also believes, that only the real surplus should be allowed to be exported, and that export should not be subsidised to cause internal economic shortage. Rather our economic policy must be adjusted to the nutritional requirements of the people. Street, in his interesting novel makes his Minister of Agriculture subsidise the consumer as a method of helping the farmer in a period of national stress. This is actually being done in wartime Britain to-day, and we are told that with the addition of controlled menus this has resulted in far better health for the masses.

Over-production in an economic sense means, according to Knapp, that the supply of an article is so large that the price falls below the cost of production. That is the common complaint of the farmers—they are giving their products away and even paying for that privilege. How have we reached this state of affairs? Other economists agree with Richards, (1935: 2-4) when he gives intensive agrarian protection in the industrial countries of Europe as one of the chief causes of present troubles. He also quotes the opinion of Sir Frederick Leith Ross at that time Economic Adviser to the British Government:

> "The principal industrial countries of Europe have been engaged since 1925 in stimulating domestic production of agricultural commodities at artificially high prices. These high prices prevent consumption from expanding and absorbing the increased production. The shortage of manufactured products in the agricultural countries, stimulates the development of local industries in those countries. These local industries then claim protection against competition from the more efficient industrial products of Europe and in course of time, tend to invade their export markets, thus forcing down the prices of industrial products in the world market."

What I shall quote from Blackett (1935: 137) makes the ultimate position even clearer:

> "The failure in each country of purchasing power to absorb all that can be produced, leads to widespread unemployment, to a violent drive to open up new markets abroad, and at the same time to the attempt to create more employment by tariffs and quotas. It is perfectly clear, that it is the internal economic condition of a country that drives it simultaneously to economic imperialism and economic self-sufficiency, and therefore to violent nationalism and war, rather than that, as some people seem to think, the violent outbreak of nationalism all over the world is a sort of spontaneous thing with no real causes."

These opinions epitomise what is generally accepted as the cause of present world trouble. Fascism, Bernal believes, is the logical result of restricted capitalism.

After reading Keynes on "The Economic Consequences of the Peace" I cannot but conclude that the foundations for future trouble were well and truly laid in 1919. A sincere attempt at ethnological justice may have been made, but apparently economics is of more importance in the world as constituted to-day. Fundamental economic problems were left severely alone, which is understandable in the emotional atmosphere of hate and revenge existing at that time and with political elections looming on the horizon. The sad results we are now experiencing. The right of peoples to self-determination seems to have changed to a right to self-extermination. Clemenceau criticised Keynes rather harshly in his introduction to Tardieu's "The Truth About the Treaty," but history has justified Keynes' views.

THE NEGLECT OF AGRICULTURE BY ECONOMISTS

Van der Post points out, that until quite recently. economists have neglected agriculture and devoted themselves from the time of Adam Smith to the close of the nineteenth century mainly to the easier study of industry and commerce.

> "Probably the explanation is to be found in the fact that the operation of economic law is not so readily discernible in agricultural activity as in industrial enterprise, since in the latter, man has a larger measure of control over conditions of production and consumption, whereas in the former, he is all too often at the mercy of unstable elements of climate, soil and weather."

Knapp is in agreement with these views and quotes Eduard David as saying:

> " The gate to the knowledge of economics is not a contemplation of industrial development but a study of agricultural production."

There is complete agreement among all authorities that the science of production is far ahead of that of distribution. Blackett puts this more epigrammatically:

> " The disastrous gap between the potentialities of production and the actualities of distribution must be bridged."

Our Division of Economics has endeavoured so arduously to bring this about in government policy, that in 1938, Biljon brought out a book called " State Interference in South Africa." Richards in 1935, too, criticizes the government policy which was largely the outcome of the work of that Division, drawing attention to what he calls, the heavy and unnecessary expenditure in South Africa in 1933 of £8,646,000 to assist the farmer, and points out the economic consequences of a policy which offers no permanent solution to the agricultural problem. General Smuts, in his foreword to this brochure, points out that, however true the criticism may be from the economist's viewpoint, the author has not dealt with the situation from its larger national and social aspects. What would have been the state of affairs if such action, afterwards continued for several years, had not been taken?

> " It may be that if the price had not been paid, the resulting loss to the community in social and economic disorganisation would have been far heavier."

The evil is world-wide and cannot be solved by any one state alone but only in co-operation with many others, and when all are prepared to make many sacrifices. Knapp agrees that the direct support of agriculture by the treasury is no solution. These measures are admittedly expensive palliatives which can only be dropped entirely when there is better international co-operation for the common good. When agriculture is criticized by commerce and industry, the heavy protection many local industries enjoy is not mentioned. This protection allows them, as Elliot points out, to collect their own subsidies, which may amount to more than the direct State help agriculture receives. Leppan agrees that:

> "Economic planning for national self-sufficiency without world correlation causes chaos."

There is no doubt that agriculture has not been given the serious attention in international politics and economics to which it is entitled. The age-old Chinese view is as true to-day as when the philosopher first formulated the saying: "The state is like a tree of which agriculture forms the roots and industry and commerce the stem, branches and leaves. When the roots are injured, the leaves drop, the branches wither and the tree dies,"

THE FUNDAMENTAL DIFFERENCES BETWEEN AGRICULTURE AND INDUSTRY

Knapp makes the fundamental differences between Agriculture and Industry the basis of his thesis:

> "One of the great mistakes generally made by urban economists is, placing on the same level, or in any case not sufficiently differentiating between, the agrarian and the industrial process of production. The two processes are, however, entirely different in character. In cultivating the soil, one has to deal with organic, in industry with mechanical processes of production. This follows from the fact that Nature plays the principal part of all the factors necessary for producing in agriculture, whereas in industry, labour is the leading factor. This distinction is really the root of all the differences between the two branches."

Industry can in addition, use more labour per unit of ground space, and more use can be made of machinery. The control of output is fairly simple as the machines have dead matter with which to deal. Agriculture is beset with natural and climatic risks as well as economic ones. Capital does not circulate so quickly as in industry nor is its turnover so great. Man, with his combined sciences, can make little difference to the length of the season of growth of cereal crops or the time for maturing animals.

> "The cost of production in Agriculture rises as the yield of the soil is brought up to the maximum, whereas in industry, the reverse takes place as the machine is worked up to its full capacity."

The law of diminishing returns in agriculture plays a greater part in our economic structure than many industrialists and socialists realize. The study of its interactions will make it clear that hard work alone will enable man to provide the necessities of life and raw materials for production. Nature is not equally generous in all areas, due to poorer soils, lower rainfall or hungrier pests, and will thus not allow a standard wage scale conceived by industrial labour to be applied to agriculture:

> "Nature, however, does not allow herself to be dictated to by human organisations or human institutions. If an attempt be made to force Nature to submit, as has been done on all sides during the last few years, society arrives at a deadlock, as witness the present state of affairs."

Democracy has supported social measures in conflict with the truths of Nature, and as a consequence, a great deal of social injustice has been done to the farmer. The neglect of the rhythm of Nature and an endeavour to speed up production and improve workers' conditions has led social reformers up a blind alley.

> "In our modern society, where the industrial employers and workers are strongly organised, those who depend for their livelihood on the cultivation of the soil are invariably the ultimate victims. Everyone would regard it as a social injustice of the first order, if it were proposed to compel the agricultural population by law to pay all the expenses of the social legislation on behalf of all the workers. And yet this is exactly what the present system of social insurance in countries where agriculture is not protected or supported in some way or other amounts to."

In South Africa, the white farmer can still pass on some of the social burdens to the Bantu, in the form of low wages, and rations his own prize pigs would die on. The Bantu, for the present can pass them on only to the spectres of squalor and malnutrition. This must be considered only a temporary solution. Several of our economists have pointed out that South Africa's own purchasing power is low, chiefly on account of the poor wages the Bantu receives. Knapp believes that if agriculture is taken as the touchstone and basis of economics, stabilized prices abolished, and free trade and competition allowed to bring about a natural balance, the world will get a chance to regain its equilibrium. He admits, however, that the restoration of free competition means, that great sacrifices will have to be made, and many privileges will be lost. It also means that wages and salaries for everyone will be on a lower scale, but as their purchasing power will be correspondingly greater, the effect of this adjustment will not be so distressing as it appears at first glance.

> "As a result of the restoration of free competition, a natural order will hold sway in society, the organic relation between agriculture and other industries will also be restored. Consequently, agriculture will again be brought into line with other branches as regards the determining of wages and prices, so that it will once more become paying. The placing of agriculture, the natural foundation of society, on a sound basis, will also exercise a favourable influence on other industries. The farmers and farm labourers together forming nearly two-thirds of the population of the world, will once more be able to exchange their services and their products for those of urban concerns."

Richards and Sir Daniel Hall substantially agree with Knapp in his advocacy of world-wide free trade, although Richards' view (1933: 98) makes some allowance for social reform. He says:

> "The specific task of this age is to fashion a system in which competition and individual enterprise on the one hand and regulation and general planning on the other, will be so adjusted that the abuses of each will be avoided and the benefits of each retained."

The effort to improve social conditions should not be considered as a class struggle but rather one in which man is striving to bring his works into harmony with Nature so that he may be at peace with his environment.

Is Socialism a Remedy for Agriculture's Ills?

Many believe that it is the only remedy, but Knapp indicates that socialism can never be a success, until such time as science succeeds in synthetically producing flour, milk, meat, wool, eggs and dairy products, at a cost lower than the farmers, and moreover, these products should be cheaper and cheaper as production increases and not dearer as is often the case in Nature. The best answer is found in the case of the Soviet Republics which attempted to socialize agriculture on a magnificent scale. The results they obtained somewhat stemmed the tide of communism and forced the commissars to alter their tactics. By March, 1932, orders were issued to cease all efforts to effect compulsory collectivisation of the cattle and flocks of the peasant farmers and to organise the buying of breeding stock for those who did not possess any livestock. Furthermore, by May of that year, those farmers who had delivered the fixed quantities of grain to their Soviet, were allowed to sell their surplus in the open market. Shortly afterwards the total quantity of meat and grain that had to be supplied was reduced by half, which occasioned still further astonishment. Finally a third decree gave farmers the liberty to sell butter, cheese, eggs. vegetables and fruit. These decrees, based on experience and results, showed that:

> "Agriculture is the weak spot in the economic policy of Soviet Russia and that the laws of economics and psychology, although not perhaps rendering it necessary to return entirely to the capitalistic method of production, have nevertheless necessitated a strong tendency in that direction. This change of policy is especially reflected in the partial re-introduction of the stimulus of self-interest, in the tendency to transfer the point of gravity from consumption to production and the strengthening of individual responsibility."

The stinginess of Nature and her indifference to socialistic dicta, make the production of her fruits difficult Often, too, all labour is vitiated by storms and insect plagues. Nature will not fit into a world organised on a labour basis. The only alternative is for labour to attempt to get into harmony with uncompromising Nature but it would seem that mankind is to suffer severely before this truth is appreciated by labour and by those who use labour, only for their own material ends.

ECOLOGY AND WORLD STABILIZATION

The ecological attitude to world problems is essentially holistic. This viewpoint was carefully expounded by Bews in 1931 and 1935 and by Phillips in 1932 and 1939 and is now generally accepted as a sound method of approach to national and international problems. When ecology is considered in relation to the world's food supply and raw materials, we come back to its original botanical concept. We appreciate then, that certain combinations of soil and climate will allow certain crops to grow more easily and produce more plentifully under those particular conditions than in areas where these factors are not so well balanced. When we grow these crops under less suitable conditions, we find that their yields are lower and they are more subject to diseases and pests. It follows then, that if we wish to provide man with his food, fodder, and materials for manufacturing his requirements in the cheapest manner. these crops should be grown in those areas best suited to them and sent from there to where they are required unhampered by politics. As soon as this natural production and distribution is restricted, costs of production are increased and quotas, tariffs, bounties and subsidies come in action.

To what absurd and cruel lengths these artificial methods of regulation can go, those living in the present chaos know only too well. It is artificial pressure of this nature which has made farmers squander the capital of their natural resources, in order to meet the excessive demands of commerce and industry which should thus take as much blame for soil erosion as the farmers.

Few will disagree with Huxley's view that:

> "Scientific planning whatever kind of society one may want to achieve must be based on world economics and world natural resources."

A simple statement of truth, but it might well be a hundred years or more before it can be stated as a fact rather than as an aim. Graham states that:

> "To the ecologist there is real significance in the adage that man must learn to work with nature, not against her. To-day we hear more and more about ecology. We hear that the conservation of resources is attainable only if founded upon ecological principles; that many subjects, such as geography, are properly taught only when treated as human ecology; and that the tumultuous unrest of the world to-day exists only because man has held more to political than ecological tenets."

The doctrine of the free traders that every crop or product should be produced in the area best suited to it on account of soil, climate, labour conditions, or industrial technique, is sound ecologically and economically. When this is ignored, protection must be introduced for the less suitable areas and at once prices are forced up for the home consumers. "Protection" says Knapp,

> "therefore amounts in practice to the checking of progress and is in that respect to be compared with the opposition to the introduction of machinery in former days. The community can only be saved by restoring natural order and this is only possible when there is free competition in every section of industrial life."

Richards states that Frederick List, the protagonist of protection, condemned the protection of primary products, since their geographical distribution is determined chiefly by unalterable physical conditions.

Knapp believes that:

> "the welfare of the world is promoted best if the goods are produced where this can be done cheapest in consequence of natural circumstances. Such a state of affairs is only possible

> with free competition for all products. The production will then be as great as possible, while the international exchange of goods will attain its maximum value. The riches will consequently increase most, so that there will be the maximum amount to distribute. Briefly, the social requirements will be best met if the economic requirements are best complied with."

and we might add, sound ecology begets sound economy.

The ecological viewpoint thus supports the idea of free trade with all the countless difficulties and sacrifices it must entail for the ultimate good of mankind as a whole. Such a viewpoint will be far from popular, as it will probably affect our own secondary industries severely and also a number of our heavily protected agricultural products.

There are alternatives; we can try to continue as we are doing, if we have not yet learned our lesson and wish to prepare for another war in twenty years time. In the meantime, agriculture will probably have to be subsidised more heavily than ever, if it is not to decline and land us in local social disasters. We might try keeping the cost of agricultural products high and subsidise the consumer instead. Then the state might even take over all the land and produce the food and raw materials required, which would undoubtedly increase their cost. However, all these suggestions are out of harmony with nature and therefore must be considered as palliatives, they are too rigid for our dynamic world.

Cardon is of opinion that:

> " The economist will contribute most if he strives always to discover and clarify economic laws, which can be brought into position alongside of, and in harmony with, the physical and biological laws upon which agriculture is founded."

Richards (1932: 132) suggests as a measure for relieving economic pressure that a continent like Australia could take a greatly increased population. Richardson admits that the better rainfall areas of Australia might possibly carry two and a half times as many people as at present. He reckons, however, that the 15 inch rainfall areas are already fully settled if not over-settled. Furthermore, it should be remembered that although Australia has large open spaces. one-half to two-thirds of these areas are desert or have too low a rainfall for intensive settlement. The same applies to South Africa, of which about a quarter enjoys 25 inches and over, while more than half has less than 20. At least

30 to 50 inches of rainfall is needed for intensive settlement and land in such limited areas could probably sustain a population five to ten times as great as at present. This suitable area would constitute about one-twentieth of the whole Union. Many critics are sure it is agriculture's own inefficiency that is its chief trouble. Weitz shows, however, that in the United States there was a big increase in the crop yields per acre between 1885 and 1924, and the increase was not due to the exploitation of new lands, as he had been careful to avoid this pitfall The soils of north-western Europe, he says, are producing high yields, whereas 200 years ago their yields were actually on a par with some of the poorest soils in the U.S.A. to-day. This indicates that all the fault is certainly not on the farmer's side.

The ecological idea is growing. Recently Southern Rhodesia set all African states an excellent example in her "Bill to make provision for the conservation and improvement of the natural resources of the Colony and for other matters incidental thereto . . ."

> " It establishes once and for all the principle that the land, the physical foundation of the state, is a trust that must be handed on to future generations unimpaired, except in so far as minerals which have been removed."

Beams of hope are visible through the gloom. Everywhere men, in all walks of life from the duke to the dustman, are discussing a better organised world for the future. The idea of Federal Union in outline, anyway, appeals to the man of average intelligence. Prominent statesmen like Anthony Eden and journalists like William Hard are giving support to the federal concept as a method for obtaining world security and peace. Richards in 1932 ventured to suggest that the concept of larger economic areas born of economic necessity would possibly spread.

The groups he listed were: (1) The British Empire. (2) The Americas, (4) The United States of Europe, and (4) An Asiatic Bloc.

This is very similar to Hard's proposal in February 1941. except that he disassociates Great Britain completely from Europe and links the British Commonwealth with the Americas. Such groupings would fit in well with the idea of free trade over larger areas. The idea is sound ecologically and the ideal and the concept are well worth working for

General Smuts also gave it his blessing in a recent broadcast. He said:

> "We are unmistakably in for larger human groupings in that holistic process which fundamentally moulds all life and all history."

SCIENCE THE CHIEF AGENT IN SOCIAL CHANGE

Most men realise in a nebulous way that science has brought about great changes in the social structure but not always beneficial ones. The masses must be taught that science is their ally and not their enemy and that it is absolutely necessary to help them to attain social justice, peace and liberty. The scientist too, must realise how great a part he has unwittingly played, and how he can in the future be even a greater instrument of good for humanity. The worker and the scientist must both learn to appreciate their mutual inter-dependence. The form science takes is largely determined by the industrial needs of the country where it is found. Capitalism gave science its start and enabled it to develop. This combination benefitted both considerably, and also gave more work for labour. Industrial needs, however, require chiefly the physico-chemical and mechanical sciences and by the opportunity given them, these have developed out of all proportion to the biological and social sciences. As a result of this lopsided, misdirected development, and the changes it has brought about, the world is to-day in chaos. A serious endeavour must be made to restore its natural balance. In the larger economic units of the future as envisaged by various forms of Federal Union, there will be a great saving in armaments and in the research devoted thereto. This money could be used for no greater benefit than for research in those sciences which will benefit all men rather than a few individuals. In South Africa, our principal research work deals with mining, metallurgy, fuel and biology as applied to agriculture and medicine. South African research maintains a better balance between inert and living matter than is the case with science in most countries to-day. Our Division of Economics has also taken up a considerable amount of the slack which existed in that field, but for the social sciences there is a vast territory mostly unexplored. Few scientists can be free agents, they must seek their bread where their services are required and, if there are only a few economists and still fewer sociologists, it is not that they cannot qualify but that they cannot find employment. Society has reached the stage when sociological work on a large scale is an urgent need, but this has not yet been recognised sufficiently to induce action. It is difficult to envisage society employing sociologists and economists and organising research which will show the great need for changes in that society and ultimately bring them about. Huxley pointed out in 1934 that in England, there was no Economic Research Council, only an Advisory Committee, but not even the latter for social sciences. When we see to what extent the masses are managed by psychological means in the totalitarian states, it is evident that we in the democracies, are somewhat backward. Could psychology not have been applied more vigorously to give the spiritual and ethical ideals of democratic states a mass focus, to stir once again their sagging souls and restore their pristine dynamic drive? This has now been done by war, but at what a terrible cost.

In 1933, before the British Association, Lord Stamp, who was recently the victim of a bombing raid, made a strong appeal that as many as possible of the best scientific brains of the younger generation should be guided away from the sciences of matter, physics and chemistry into the sciences of life, biology, psychology and sociology, in order to strive for a better balanced world. Huxley says:

> "We have got a great deal of control, quite enough to get on with for the time being, over lifeless nature; we have practically no control over human nature, and over the monsters we have unconsciously created, or at least allowed to grow up unchecked, in the shape of economic systems, unintelligent minorities, national sovereign states, mass ignorance and mass hysteria."

Alex Carrel put it even more strongly:

> "The enormous advance gained by the sciences of inanimate matter over those of living things is one of the greatest catastrophies ever suffered by humanity."

From the trend of events to-day, it would seem that the end of the era of inanimate science, unbalanced and used only for man's material needs, is in sight and that if more attention is given to the sciences of man and of nature, the generations to come should inhabit a more harmonious and a happier world.

THE SCIENCE OF MAN

The rhythm of life rolls slowly on, but its beat is strong and irresistible. Man has been so long lost in admiration of his mechanistic achievements and their accelerating tempo that he has lost step with nature. Unfortunately he seems for the most part spiritually unaware of the discord he has produced and of the fact that nature will tolerate no rival orders. All man's inventions and discoveries must be so adjusted as to tune in to the wavelengths on which nature operates or they will react adversely on their creators. Man must study and understand himself before he tries to change the world order. Wilson, Under-secretary of the United States Department of Agriculture, puts the problem in these words:

> "We achieve perfection relatively speaking in a part of man's affairs, the part concerned with the technology of production, but it is useless because it does not fit in with the whole. We do not yet understand what the harmony of the whole is . . . To discover these broader inclusive harmonies is a function of what has been called a new science of man, of which all other sciences will be a part, in so far as they relate to human affairs. Man, by using his brain, developed a terrible efficiency within narrow limits. But the question is, whether in so doing this, he has not ruthlessly disregarded a natural balance of his own nature."

Let us now hear the views of a medical authority of world-wide repute. Carrel concentrates on the holistic viewpoint and thinks that the more eminent the specialist, the most dangerous he is, unless he correlates his diagnosis of man with those of many others, he says:

> "We do not apprehend man as a whole. We know him composed of distinct parts and even these parts are created by our methods . . . We are very far from knowing what relations exist between skeleton, muscles, and organs and mental and spiritual activities. Man should be the measure of all. On the contrary, he is a stranger in the world that he has created. He has been incapable of organising this world for himself because he did not possess a practical knowledge of his own nature . . . The restoration of man to the harmony of his physiological and mental self will transform his universe. We should not forget that the universe modifies its aspects according to the conditions of our body."

So far as I am aware, Alexander is the only man who has developed a philosophy and a technique with which to restore to man his psycho-physical harmony. His concepts, methods and results obtained in a lifetime of teaching and applying his technique are elaborated in his three books to which I make reference. One day I believe the outstanding contribution which Alexander has made to human welfare will receive the belated recognition it deserves from a grateful world and he will take his place among the immortals. Unfortunately, his principles and technique are not as easy of application as those of Pasteur and cannot be applied in the mass and consequently make far slower progress, although they are now constantly receiving recognition even in the "British Medical Journal." I gave this matter some attention before the South African Chemical Institute in 1938, and have since then benefitted personally from its teachings and technique more than ever I had hoped to do, but to get its full benefit you must be caught young. As the only teacher of the Alexander technique in the Southern hemisphere, Miss I. Tasker, is reading a paper on certain aspects of this work before the Association, I shall say little about it but quote a statement from Alexander's earliest book written in 1916.

> "One of the most startling fallacies of human thought has been the attempt to inaugurate rapid and far-reaching reforms in the religious, moral, social, political, educational and industrial spheres of human activity, whilst the individuals by whose aid these reforms can be made practical and effective, have remained dependent upon sub-conscious guidance, with all that it connotes."

Horder stated before the British Association in 1936 that functional diseases compared with organic, had increased considerably. This coincides with Alexander's views that man has been unable to adapt himself to the rapidly changing environment of the past hundred years by relying on his instinctive or sub-conscious control: This has brought about inefficient functioning and the train of troubles resulting therefrom. Not until man can achieve a conscious control of his psycho-physical self, and so restore his own harmony. will he be able to undertake the control of the better balanced world he visualises, in which sciences will be unified, integrated, and co-ordinated for the benefit of humanity as a whole. Bernal believes that the tragedy of man has too often lain in his very success in achieving what he imagined to be his objects . . .

MAN'S SPIRITUAL DEVELOPMENT

However important the psycho-physical and materialistic aspects of man's well-being may be, if the spiritual is neglected, retrogression is sure. I could not express it as well as Sarton does and therefore defer to him:

> "The scientific spirit must be itself assisted by other forces of a different kind, by religion and morality. Truth, however precious, is not the whole of life, it must be completed by beauty and charity."

General Smuts in his presidential address to the centenary meeting of the British Association spoke prophetically as he so often does:

> "While religion and science are still separate values, they may not always remain such. Indeed, one of the greatest tasks before the human race will be to link up science with ethical values and thus to remove grave dangers threatening our future. A serious lag has already developed between our rapid scientific advance and our stationary ethical development, a lag which has already found expression in the greatest tragedy of history. Science must itself help to close the dangerous gap in our advance which threatens the disruption of our civilization and the decay of our species."

Alas! either science disregarded his words or there was not sufficient time to put them into universal practice, and once again we are witnessing one of the greatest tragedies of history. Through the debris and dust of this second great crash of civilization, we see faintly signs which are indicative of hope. Everywhere men are realising how precious are the rights of man and his freedom. Never was war held in quite such abomination by so many except as a means to crush evils worse than war. Many appreciate the pernicious part that lopsided and ill-directed science has played in bringing about the catastrophe. We have thus the advantage over previous civilizations which passed into decay, in that we know that we have transgressed natural laws, and why we are being punished, and there is therefore a chance, that out of the unhappiness of our present materialistic civilization, there may arise another more in tune with the universe, in which the chief work of science will be to improve man's conditions and make him healthier and happier. In such a world, literature and the arts will have a better chance for development. The agricultural chemist will again come into his own in aiding the farmers to produce better food with higher yields, to meet the demands made by a more equitable distribution of the fruits of the earth.

A SUMMARY: AND THE FUTURE?

In this brief and somewhat superficial survey of certain aspects of our sick civilization, I have tried to point out that:

1. Agriculture, despite man's technological progress, is as necessary to his existence and happiness as ever it was, and is still the world's largest industry.

2. Agriculture's troubles are not due primarily to local inefficiency but rather to political, economic and social mal-adjustments on a world-wide scale.

3. Agriculture was neglected by economists too long for the easier and more spectacular study of industry.

4. The fundamental difference between agriculture and industry is not sufficiently appreciated by industrial economists and those interested in social reform. Agriculture deals with organic and industry with mechanical means of production. In agriculture, Nature plays the chief part in production, but in industry, labour. As you increase production in industry, you decrease costs, but the law of diminishing returns operates in agriculture and Nature is stingy with her gifts. Social reformers have been trying to force upon uncompromising mother Nature their selfish schemes devised for labour with man-made, and controlled machines. Nature is entirely indifferent to these socialistic dicta, and the world will never regain its harmony until men realise it, and try to adapt themselves to Nature's old order and rhythm and then they may comprehend they have really discovered the new order.

5. The best way to bring this about is to allow unrestricted competition, and crops and raw products to be produced where they can best be grown and so obtained most cheaply. This will necessitate considerable sacrifice to start with, but these ills will certainly not be more painful than those society is bearing to-day. In due course more wealth will be produced and foodstuffs and goods will become cheaper and more equitably distributed. This concept is sound ecologically and should help greatly to restore stability to the world, but will certainly bring about lower wages and salaries all round. This will, however, be offset by money having a greater purchasing power.

6. Science is acknowledged to be the chief agent in social change but, because it has had a lopsided development, due to industry stimulating chiefly the physico-chemical and mechanical sciences, it has helped to cause the present chaos. There is far greater need to develop biological, psychological, and social sciences, in fact society will never get its full benefit from science until this is done, and so it must demand immensely increased research in those sciences which will augment the health and happiness of all men.

7. The science of man has been most neglected. Man cannot hope to control a complicated world until he understands and can control his own psycho-physical being on a conscious instead of

a sub-conscious plane. There is evidence that great strides must be made in the science of man before we can expect to make much progress.

8. Finally, ecologically, politically, and spiritually, the idea of larger world economic units for the purpose of simplifying trade and exchange, and improving human intercourse and understanding is a sound one. The idea of Federal Union or a regenerated League or a combination of both, appeals to all men who love liberty and peace and a chance to develop their souls. A peace economically just is envisaged, as a permanent peace can never be planned on a punitive basis. This time the slogan should be not "*self-determination and independence*" but rather "*self-adjustment and inter-dependence.*"

Man has fine ideals towards which to strive and if we are true to them, and with the aid of science unselfishly controlled, our grandchildren may still live to see the day when most men will truly say "Above all Nations is Humanity."

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THE DESIRABILITY OF A PAN-AFRICAN BOTANICAL POLICY

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Presidential Address to Section C. Read 30 June, 1941.

The desirability of a Pan-African botanical policy is indisputable. In considering the subject, the questions of political boundaries and differences in administration do not arise. But when considering the practicability of such a proposal these factors are obviously of fundamental importance. The present chaotic state of international relationships has convinced most of us that there is, without doubt, room for a new and better order after the conflict is over. That some system of federation is essential to the rationalisation of African affairs is also apparent. Nationalism stimulates competitive instincts. Botany, and I wish to speak mainly of taxonomic botany, is one of the sciences least dependent for its progress on the competitive instinct. Competition in this field, except in a mild form, may endanger real progress. The new order must be co-operative, not competitive. Unfettered science generally is international in outlook, and unity in our botanical purpose should be easier to attain than the political unity of peoples and states. Hence, I feel, to voice support for a Pan-African botanical policy, even at this time, is not too preposterous.

A united Africa from the " Cape to Cairo ": this was the call of Rhodes. True, Cecil John Rhodes was not a botanist, but had his vision materialised, and it still may, a Pan-African botanical policy would be relatively simple to achieve. The idea is not a new one. At the Pan-African Agricultural and Veterinary Conference held in Pretoria in August, 1929, Dr. I. B. Pole Evans, founder of the Botanical Survey in the Union of South Africa, asked the Conference to consider the desirability of undertaking a botanical survey of Africa. He pointed out that such a survey has two aspects in view—the scientific and the economic, the latter depending on the former. The scientific side is concerned with the identification and naming of the plants, the comparison of the floras of different areas, and the determination of their history and origin, while the economic side is mainly concerned with their agricultural and industrial value. The conference agreed to the proposal in principle and it was recommended that the Government of the Union should approach the Governments of all African States and Dependencies and invite their co-operation in the carrying out of the botanical survey of Africa. In the same year the Rt. Hon. General J. C. Smuts, in the course of his Rhodes Lectures at Oxford, made the suggestion of an African Research Survey.

Not a great deal of progress has been made in the interim. It is true that Dr. Pole Evans has himself broken new ground by planning and undertaking extensive botanical expeditions outside the boundaries of the Union. General Smuts, too, whose interest in botanical research is well known, has given impetus to the project by example. Several botanists from African territories have visited the Union and furthered the cause of closer collaboration. But, by comparison with the magnitude of the undertaking, only the fringe has been touched.

A Pan-African botanical policy is so obviously desirable from a scientific point of view, that one might say that there is no need to labour the point. On the other hand any arguments in its favour may bear fruit in time, and I shall endeavour to draw the attention of the meeting to arguments in favour of only the scientific aspect as outlined by Dr. Pole Evans, as it affects the identification of the plants and the study of the flora of different areas. The more obvious economic advantages are not so readily overlooked. Arising out of General Smuts' suggestion for an African Research Survey, informative reports were prepared by Lord Hailey, the chairman of the African Research Survey Committee (*An African Survey*) and by E. B. Worthington (*Science in Africa*). These reports reviewed the problems and progress of African Science, including botany. Worthington opens his remarks on taxonomy with a truth which is rarely appreciated outside scientific circles, namely that "systematic studies are an essential preliminary to all branches of biological work, and in themselves make important contributions of a general as well as a special nature."

For the correct understanding of the flora of the African continent, to classify the component parts, study them collectively and see them in their correct perspective, it should be studied both in detail and as a whole. Artificial national boundaries have no place in nature and these must be ignored as far as possible. One may turn for a moment to past achievements. Past achievements are judged by the published literature. A review of the entire literature relating to the African flora would be a long story, and all I intend doing is to mention but a very few works which may act as a background to my subject.

In the 18th century the focus of botany was in Sweden led by Carl Linne or Linnaeus. A. P. De Candolle took the lead early in the 19th century with his *Prodromus* and was followed in turn by the combination of Bentham and Hooker in England, and Engler in Germany. Apart from the *Genera Plantarum* of Bentham and Hooker with its general application, and *Flora Nigritiana* by Hooker, these two authors contributed relatively little directly to the literature, but they instituted a series of colonial floras, which, in time, led to the partly concurrent publication of the *Flora Capensis* and the *Flora of Tropical Africa*. Between them, these two Floras consisting of 7 and 10 volumes respectively, cover the greater part of the flora of the African continent (omitting only the flora of the Mediterranean region because of its largely European affinity). The *Flora Capensis* and the *Flora of Tropical Africa* combined, constitute the nearest approach to a uniform systematic study of the flora of Africa.

The great personality of Engler brought botany to the forefront in Germany about 1880. He established the periodical *Botanische Jahrbucher* in 1881, which included many contributions on African botany. To this, in collaboration with Prantl, he added the *Pflanzenfamilien*, but his first large work devoted entirely to African botany was *Die Hochgebirgsflora des tropischen Afrika*, followed by an interrelated series under his editorship, *Die Pflanzenwelt Ost-Afrika*, *Monographien Afrikanischen Pflanzenfamilien-und-gattungen* and *Die Vegetation der Erde*, volume 9 of which, consisting of several parts, was devoted exclusively to the vegetation of Africa, and covered the whole field.

In the same period, works of a comparable nature to the *Botanische Jahrbucher*, all with a bearing on African botany, were established, in England (*The Kew Bulletin of Miscellaneous Information* and the *Journal of Botany*), in Belgium (*Bulletin du Jardin Botanique de l'état de Bruxelles* and associated with this *Annales du Musee du Congo Belge*), in France (*Bulletin de la Societe Botanique de France*), in Portugal (*Boletin da Sociedade Broteriana*), in Switzerland (*Bulletin de L'Herbier Boissier*), to which list may be added several others. These periodicals are supplementary to many works published over a period of roughly three centuries, to regional floras dating back to Thunberg's first *Flora Capensis* in 1823 up to *Flora Somala* by Emilio Chiovenda and the recent *Flora of West Tropical Africa* by Hutchinson and Dalziel: supplementary also to detailed accounts of collections made by individuals or by organised expeditions, for example, Burchell's *Travels in the Interior of South Africa;* the *Catalogue of Welwitsch's African Plants, Mission Emile Laurent* by E. de Wildeman, *Voyage en Abyssinie* by Richard, *Der Schwedischen Rhodesia-Kongo Expedition*, and a host of other works of a general nature, such as check lists of species, and others on specialised subjects do not lack examples. Nearly every European country has made its contribution and the United States of America has carved a niche for itself in such fine works as the 3 volumes on the *Stapelieae* by White and Sloane, *The Vegetation and Soils of Africa* by Schantz and Marbut and by the dedication of volume 6 of *Herbertia*, the official journal of the American Amaryllis Society, to the *Amaryllidaceae* of Southern Africa. The contribution made by South African botanists to the literature of their own flora surpasses in its comprehensiveness the literature of any other one territory, and this is not unnatural considering its longer term of European settlement. One has but to mention such names as Bolus, Medley Wood, Sim, Marloth, Schonland, Bews, Pole Evans and Phillips to conjure up visions of an impressive series of publications covering a wide field of South African botany.

A fairly extensive and representative, though by no means complete, bibliography of African botany is to be found in *Science in Africa* mentioned earlier. With so much accomplished, it may be asked, what remains to be done? And yet one may say with justification, that the great contribution already made is in reality only a small fraction of what there is to do. It is a foundation soundly laid on broad lines in preparation for more intensive co-operative work in the future.

Botanists interested in African botany, in fact workers in any branch of science in Africa, should have a common meeting ground in Africa, a central clearing station in the midst of our flora where ideas may be exchanged, co-ordinated and common standards evolved. We must progress beyond the present isolationistic principles. Under present conditions, a botanist's conception of the flora is more often than not strongly coloured by his nationality. The Belgian botanist concentrates largely on the plants of the Belgian colonies, the French on the plants of the French colonies and the Portuguese on theirs and so on. On the other hand it has been shown that botanists at Kew and Dahlem have endeavoured to take a broader view. This has been made possible mainly by the very extensive herbarium collections built up at the respective institutions. The Royal Botanic Gardens, Kew, contains the most representative collection of the world's flora in any one institution, and the collection at Dahlem, Berlin, is possibly the next largest, at least as regards the African flora. But neither institution is equally well represented from all areas. Taking Kew as an example, the collection is disproportionately rich in the floras of the British colonies as compared with those of Belgium. France and Portugal, and *vice versa.*

In the early days of botanical exploration all the plant material collected by explorers was shipped to Europe to be lodged in numerous herbaria and to be described by resident botanists. Consequently most of the type specimens on which our nomenclature is based are still preserved in Europe, at Upsala, Stockholm, Vienna, Geneva, Zurich, Kew, Dahlem, Paris, to mention only the more important centres. Herbaria in the colonies and the Union of South Africa are relatively young institutions. While herbaria were being built up in Europe during the 18th and early 19th centuries, no herbarium was as yet founded in Africa and it follows, therefore, that the percentage of type specimens of the African flora now in Africa is comparatively small.

The establishment of regional herbaria, to specialise on the local flora, should be encouraged, but the number of herbaria serving any one area should be reduced to a minimum. Both efficiency and economy are served better by one well equipped herbarium than by two herbaria indifferently equipped, not the least important item of equipment being the professional staff.

In his presidential address to this Section in 1930, Dr. E. P. Phillips, chose as his subject, *The Rise of Botany in South Africa.* in which it was pointed out that the first colonial botanist, Pappe, instituted the policy of local herbaria. But of the herbaria at present in existence in South Africa, the Bolus Herbarium, now attached to the University of Cape Town, has the longest history, having had its beginnings about 1855, whereas the youngest herbarium of importance, the National Herbarium, only came into being after 1900. The growth of the latter, however, has been phenomenal with the incorporation of the older private herbaria of Galpin, Flanagan, Dieterlen and Marloth. The establishment of herbaria in other parts of Africa are also of comparatively recent history.

Thus a worker wishing to monograph a genus distributed throughout Africa must, if the work is to be of practical value, either examine personally the relative material in Europe or obtain the close co-operation of workers in the oversea herbaria. Nor must one measure our dependence on oversea institutions solely in terms of specimens. The relative literature is of equal importance. There are books relating to South African plants dating back to as long ago as 1687 when Breynius set the ball rolling. An excellent South African botanical library has been built up at the Bolus Herbarium. The National Herbarium also has a very valuable botanical library, relative not only to South African botany but to Tropical African botany as well. Excellent though both these libraries are, there are many gaps, which are not readily filled owing to rarity or expensiveness, or both, of the books, in fact some books are, practically speaking, unprocurable.

There has been in the past, though now temporarily dislocated by world hostilities, a large measure of co-operation and a free interchange of ideas and information between African and oversea institutions, and this will no doubt be resuscitated later with renewed vigour. African botany is and is bound to remain dependent to some extent for its progress on oversea herbaria. The degree of dependence can however, with no vital sacrifice on the part of the parent bodies, be decreased gradually. This may be accomplished by building up in one African institution a comprehensive library and a representative collection of authentically named specimens—in fact a Pan-African botanical institution with an international staff with the team spirit. In such circumstances that very desirable combination of herbarium knowledge coupled with field experience would be nearer the grasp of a greater number of workers. Under former conditions it was the rule rather than the exception that recognised authorities on the African flora never set foot in Africa. Most, if not all, would have admitted this to be a serious handicap to their researches.

With the African flora being explored in all directions by many independent institutions, without any central co-ordinating body, it follows inevitably that wastage of effort must take place. Primarily the interpretation of floral investigations depends on the concept of the unit of taxonomic botany, the "species." At first sight this may seem irrelevant to the question of a Pan-African botanical policy but actually it is of vital importance. It is our foundation stone. The question, what is a species? has been debated on many occasions. Whereas we may have general agreement with Jackson's *Glossary of Botanical Terms* that a species is "the aggregate of all those individuals which have the same constant and distinctive characters," the practical application of the concept gives widely different results. It is likely that, long after the exact sciences of mathematics, physics, chemistry, etc. have reached finality, the inexact science of botany will afford scientists recreation in, we hope, friendly disagreement. Just as no two human beings, even to their finger prints, have ever been found to be identical, it is just as unlikely that any two plants could be found to be identical in all respects. What limits of variation are to be accepted for each "aggregate of individuals" or species is the responsibility of the botanist to decide. There are those botanists who ponder over the advisability or otherwise of describing new species, weighing carefully all the data at their disposal and making every effort to interpret correctly the relationship of the plant to its neighbours in the veld. There are others who hold that any plant differing in some detail from its neighbours should be described and given a specific name—sometimes the greater the number of species described, the greater the self-satisfaction of the author. Due regard must be observed for the implications and deductions which may be made from such classifications.

Similarly in the classification of species into genera one must endeavour to maintain a good balance of values. Not through conservatism alone I think, but also from practical experience, I have come to regard the conception of genera and species in our standard work in South Africa, the *Flora Capensis*, as being very well balanced, and generally speaking, not requiring any drastic modifications. Some sections are unquestionably better than others. That there exist mistakes and room for improvement is also true. But to follow in our grandfathers' footsteps is not always a sign of decadence and lack of initiative. There are bigger problems to face than to pick holes needlessly in the good work of our predecessors.

It is not always possible, in fact it is rarely possible, for the herbarium worker actually to study in the veld all the plants with which he has to deal. Nevertheless, given a plant sense, and the possession of this intangible attribute is an essential characteristic of a botanist, a practical classification is usually possible. It is for botany to attract the student who has a plant sense as its servant, rather than for the student without a plant sense to select botany for a livelihood. It is as true for botany as for any other calling that a botanist is born not made.

For a worker in botany to look upon the description of new species and genera merely as the cataloguing of plant forms, regardless of the true relationship of the plants in nature, is to blind himself to the best interests of taxonomy. Such discussions on Phylogeny and Taxonomy as arranged by the Linnean Society of London in April 1940, on behalf of the Association for the Study of Systematics, are most beneficial in our efforts to establish a uniform outlook on taxonomy. It was Dr. T. A. Sprague who, during this debate reminded us that botanists should not consider themselves in the light of inventors of systems of classification, but as discoverers of parts of an existing natural system of relationships which has been evolved through the ages. The co-ordinating characters of groups, on which families, genera and species are generally based, were discovered, not made, by taxonomists.

It is for us in Africa to get together for similar discussion, so that by the airing of opinions we may approach nearer to a common outlook. Even in South Africa we suffer from the lack of facilities and opportunities for the free interchange of ideas, which may be taken as in part responsible for occasional rather wide differences in the interpretation of specific characters.

In order to approach as near as possible to a uniform interpretation of related species of plants in Africa, as implied earlier, it is desirable that an author should revise the entire range of material of any particular group, drawing conclusions only after the consideration of all available data.

In the parts of *Das Pflanzenreich* an attempt is made to go even further and deal in one publication with all the species of particular genera and families throughout the world, but it cannot be said that use is made of all the available data in the process. Whereas complete revisions may be practicable in the case of small and endemic genera, large cosmopolitan genera are often too unwieldy to be revised satisfactorily in this manner. Such work must be completed in a conveniently short period of time, otherwise the portion revised in the initial stages is out of date before the completion of the task. In the following example it was possible for a revision to be undertaken successfully of a comparatively large group as a whole. Working with the close collaboration of many botanists and collectors, Messrs. White and Sloane revised the tribe *Stapelieae*, embracing 371 species, in the space of about 5 years. The results were published in three large volumes running into over 1,200 pages and containing more than 1,270 illustrations. Even with widespread collaboration of local workers it is impossible to exhaust the field of research. A considerable amount of new data has been accumulated in the relatively short space of time since the publication of *The Stapelieae* in 1937.

Following the successful outcome of their work on the *Stapelieae* Messrs. White and Sloane turned their attention to the succulent species of the tribe *Euphorbieae*. Whereas it was desired to follow a similar plan and deal with all related plants in Africa at one time, in order to present relationships in their correct perspective, it was not so feasible in the case of the *Euphorbieae* as with the *Stapelieae*. Since I am a co-author in the work on the *Euphorbieae*, part of which is now in the press, I may explain why it was found preferable to publish our results according to arbitrarily selected areas rather than adhering strictly to specific relationships. The most serious drawback to a presentation according to specific relationships is the incompleteness of data, and far less accurate understanding of the species from some areas as compared with others. For example, the South African species have been more fully studied than those from other parts of Africa and each regional group is in a somewhat different state of discovery. To combine the descriptions and figures of a well documented area with those of an area relatively unexplored would make a uniform presentation impossible. Such a presentation would leave an impression that the *Euphorbieae* are far more important constituents of the Southern African flora than they are elsewhere, whereas this might prove quite erroneous when other areas have been equally well explored. Here then is a good example illustrating the limitations of our present system and the desirability of a more uniform botanical policy and a greater measure of co-ordination of results throughout Africa.

Taking another viewpoint, an account of the flora of any region depends largely on the interpretation placed on the component parts or species. A comparison based on literature of the floras of two areas may be undertaken with confidence if both have been prepared by the same author. If on the other hand it is desired to compare the floras of two areas based on the work of different authors, an informative result would only be possible if one were able to assume that comparative taxonomic standards had been observed in both cases. For example, if it is desired to compare the floras of Riversdale and Uitenhage districts in the Cape Province, based on the work of Muir and Schonland respectively, one would have to work on the assumption that the standards of classification of the authors were comparable. This may be taken to be the case in most instances but not invariably so, as for example, the interpretation placed on the well-known baobab (*Adansonia digitata* L.). According to some authorities this species, and no other, occurs throughout Tropical Africa, extending from West Tropical Africa to the northern Transvaal. Certain deviations in morphology from the typical form do occur within this area of distribution, and on these differences other authors have seen fit to recognise three additional species, making four species in all in Africa instead of one. Species of baobab occur also in India, Madagascar and Australia. Thus, conclusions on the distribution of species of the baobab, based sôlely on published records, would vary depending on the literature used. Nor can it be stated categorically that an independent judge would be in a position to say that one or other of the authors had definitely erred in the degree of "splitting" or "lumping" of the forms into species. In a paper on *The Baobab* presented before this Section in 1933, Miss I. C. Verdoorn suggested that, if it be accepted that only one species of baobab occurs in Africa, it might be logical to argue that all the forms of the genus in India, Madagascar and Australia should also be referred to the African species, *Adansonia digitata*. It is an interesting suggestion, and at least the presence in these lands, now separated by wide expanses of water, of such an unique plant-form as the baobab appears weighty modern evidence in support of the Wegener theory of former land connections with the African continent.

This leads one to the subject of a correlation between taxonomy and phylogeny and to speculate on the origin of our present flora. J. F. Drege, who arrived at the Cape in 1826, was the first botanist to group the flora of South Africa into vegetative regions and to draw attention to characteristic elements in different areas. It is now common knowledge that there are two distinct floras in Southern Africa. These are known as the Cape flora, characterised by such families as the *Ericaceae*, *Proteaceae*, *Restionaceae*, etc., and the African flora. These two floras are, as General Smuts so dramatically expressed it in his presidential address to this Society in 1925, "engaged in a mortal conflict with each other; the temperate or Cape flora, slowly losing ground." It may be added that into the conflict has been thrown the influence of man, whose hand is against both floras in the shape of bush fires and stock grazing, accelerating the defeat of the Cape flora.

For the greater part of the 19th century it was held by authorities, such as Darwin, that a southward immigration from Europe was the key to the interpretation of the geographical distribution of plants; it being presumed that both the floras in Southern Africa were of European origin. But doubts about the validity of this assumption were expressed before the end of the century and evidence, both geological and palaeontological, accumulated to give a strong indication of a remotely southern origin for the Cape flora and an African origin for the other. The view is gaining ground that in the largely virgin field of palaeobotany in Africa, may be the actual solution to the problem of the origin of the whole group of flowering plants. Having touched on the Gondwanaland theory in his address, General Smuts concluded his remarks by expressing the view that in the field of palaeobotany, more than almost anywhere else, will the interchange of knowledge between neighbouring states prove fruitful and beneficial in exposing the secrets of origin and evolution of the floras now colonising the African continent.

Assuming that the weight of evidence justifies the conclusion that the African flora originated in Tropical Africa and migrated southwards towards the Cape flora, it would follow that elements of the African flora nearest the Cape would be the most recently evolved specimens of the respective species which they represent. The position thus arises that the early botanical collectors at the Cape exploring from the south, came first into contact with the Cape flora and then the vanguard or outliers of the African flora advancing down from the north; and it was a considerable period later that the main reservoir of the African flora in Tropical Africa was explored. The early collectors at the Cape unwittingly commenced the exploration of the African flora *not* from its source but in the reverse direction to the evolutionary flow. (They may be likened to the impatient readers of novels who devour the last pages before the first.) Thus in the case of widely distributed species, which extend from tropical Africa into the Cape, the individual plants which were furthest from the parent stock and might well be the least typical forms of the respective species, were collected, described and named before the discovery of their ancestral stock—the least typical form possibly becoming the taxonomic "type" of the species. Peculiar taxonomic complications have inevitably resulted. The end product of a species may show varietal differences from the parent stock, due to some slight mutation or other cause, yet because the end product in the south was described and named before the parent or typical form of the north, taxonomically the mutation or variant is the type of the species, and the typical form the variety. This paradoxical position cannot be altered under the present code of International Rules of Nomenclature and any attempt to do so at this stage might lead to confusion worse confounded. Such problems are of vital importance in the study of the African flora and require even wider attention than an African policy can afford them. The African policy is an integral part of the world botanical policy. We must pull our weight in this wider sphere also.

I shall make no specific recommendations concerning closer African co-operation but I would point out that the foundation on which further scientific co-operation may be built already exists.

CONCLUSION.

In the course of my address, I have avoided as far as possible, mention of the National Herbarium at Pretoria, of whose staff I am a member, lest I should give the impression that I regard it as the only botanical institution of importance in South Africa. It is, however, the national herbarium of South Africa, in which all of us have a possessive interest and as such it should have the wholehearted support of every one of us. We, on the staff, know from experience that neighbouring territories are only too ready to make use of our assistance. We have helped the botanists of Portuguese East Africa, Rhodesia, Swaziland and others further afield. We serve scientific workers from the Cape to as far north as Somaliland and Abyssinia where our troops are now operating. In all probability the area will soon be extended to the Sudan and Egypt, thus completing the long trail from the Cape to Cairo. The more we are able to do, the more our services are in demand. We know we could open the floodgates to volumes of unsolved taxonomic problems, had we but the staff facilities. So far we have dealt with but the overflow from the spillways. The National Herbarium is ideally situated geographically to be made use of as a focusing point in any scheme of African botanical co-operation: its central position carries with it advantages, its national character implies responsibilities. We have the foundation for constructive and creative effort: the opportunity for making a substantial contribution to the fuller understanding of the common heritage of man in Africa—the plant life of Africa. Recognition of the desirability of a Pan-African botanical policy is not enough. We must strive more resolutely for the fulfilment of the project. This may seem impossible at the present time, but the issue must be kept alive. Let us at all costs, irrespective of race or creed, preserve the integrity and foster the co-operative spirit in the science of botany in Africa. As I stated at the beginning of my address, the desirability of an African botanical policy is indisputable. I selected this subject not for the opportunity of introducing a new idea, but because I am convinced that an old idea has not received the attention it deserves. I share the dream of a greater Africa with South Africa leading the way. Mav the near future yield more tangible results in botany.

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THE ATTAINMENT AND ECONOMIC VALUE OF HUMAN PHYSICAL EFFICIENCY

BY

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Presidential Address to Section D, delivered 1st July, 1941.

1. Introductory.
2. Physical condition of the Population.
3. Assessment of Physical Efficiency.
4. Physical Efficiency of School Children.
5. The Special Service Battalion.
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7. Physical Efficiency and Intelligence.
8. Diagnostic Value of Regular Physical Training.
9. Nutrition.
10. Conclusion.

1. INTRODUCTORY.

Physical education has many objectives. These include the development of interests and abilities in play and recreation, i.e. the ability to gain pleasure from games and other physical activities. Before the war we had come to believe that the leisure-time question was becoming a serious industrial and social problem; undirected leisure was becoming a menace to society. Other objectives have economic implications: the attainment of health so that the State will not have to spend money wastefully on hospitalization and medical services; the attainment of physical efficiency for carrying out adequately the work needed by the State from its citizens.

In the midst of the most serious war in which the world has yet been involved the entire emphasis must be placed on the last of these. If democracy is to survive, the states defending it must plan to obtain from their citizens the maximum efficiency for direct military work and for the industrial organization behind it for the military machine to be effective. In time of peace a population brought to the maximum degree of physical fitness would have at its disposal potential human labour far in excess of its agricultural and industrial needs. The satisfactory employment of leisure is then a matter of social importance. In war time there can be no question of superfluous labour potential. All human energy not needed in the industrial organization must be made available for the military machine.

Under present conditions the objective of physical education is clear: the attainment by all sections of the population of the highest degree of physical efficiency in order to achieve maximal production in the agricultural, industrial, and more directly military spheres. I propose in this address to examine briefly the state of physical efficiency of the population of South Africa. Having demonstrated how grossly we have failed to attain even a reasonable degree of such efficiency I shall discuss the measures available for urgently needed national improvement.

2. PHYSICAL CONDITION OF THE POPULATION.

We have in the past adopted a complacent attitude with regard to the physical condition of the youth of the country. Rugby and athletic teams sent to Europe and elsewhere have come out more than creditably in contests with teams selected from countries with vastly greater populations than our own. The inference appeared to be justified that if from our small population of Europeans we could select such splendidly developed young men there could not be very much wrong with the population as a whole. This inference is, as I shall show, entirely erroneous. What we can legitimately deduce from their achievements is that the potential level of physical development in South Africa is high, although the actual level is deplorably low.

We give every inducement to the young people in our country who happen to show athletic promise to develop their talents further. We tend to forget all about the vast majority who never attain to our first teams in football, cricket, tennis and athletics.

The clearest evidence of the low level of physical efficiency is the prevalence of unemployment in a country with splendid natural resources and a small privileged white population. During the unprecedented economic expansion that occurred in the industrial boom period of 1935-36 there were 120,000 persons unable to obtain or retain employment among our small population of two million whites. With so great a demand for workers the fact that these people remained unemployed must be attributed almost entirely to the fact that they were unemployable because of physical deficiency.

The position among our non-European population is even worse. Although they number eight millions, we cannot, from that vast reservoir recruit sufficient labour for our mining industry. We have to import large numbers from neighbouring territories and even from northern tropical areas.

3. ASSESSMENT OF PHYSICAL EFFICIENCY.

As the result of the work of Dr. E. Jokl and his students at the Department of Physical Education of the Witwatersrand Technical College we now have available accurate information regarding the physical state of many thousands of school children of all races in the Union. I was so much impressed by the national importance of the work initiated by Dr. Jokl that I welcomed a suggestion that the South African Institute for Medical Research should undertake a scientific analysis of the data collected. A statistician in the person of Mr. T. W. de Jongh was appointed to the Staff of the Institute specially to undertake this analysis. The outcome of this collaboration is a series of papers on this important matter of national physical efficiency presented to the Association to-day. It is sincerely to be hoped that this work will be looked upon as more than an academic contribution to a scientifically interesting matter. A state of affairs has been revealed that calls for urgent remedial action by the State.

Before statistical methods could be applied it was necessary to define clearly what it was that we proposed to examine. We were concerned with physical efficiency in so far as it dictates the rate of industrial and agricultural production. Actual physical performance has therefore to be measured. But there are three factors concerned in physical efficiency; skill, endurance and strength. These, therefore, needed to be separately measured.

Muscular skill is a matter of co-ordination affecting the central nervous system. It is suitably tested by sprinting. For this Jokl uses the 100 yards flat race. Lack of skill, i.e. inadequate co-ordination slows up the runner. Insufficient control would cause him to fall if he did not unconsciously lessen his rate of running. The 100 yards sprint therefore suitably tests the degree of differentiation in the motor control areas of the brain, i.e. skill.

Physical endurance depends on the physiological state of the organs involved in the supply of oxygen to the tissues, those concerned with respiration and the circulation of the blood. It is simply tested by getting the subject to run an extended distance. For school children Jokl found the most suitable distance to be 600 yards.

Strength depends on the state of the muscular system of the body. It is suitably tested by "putting the shot."

4. PHYSICAL EFFICIENCY OF SCHOOL CHILDREN

Even before the outbreak of the War the National conscience had been stirred about the deplorable state of malnutrition among very large sections of the population. Parliament had instructed the Union Health Department to undertake a nutritional survey with a view to applying remedial measures. In 1938 I had organised a Union-wide survey. As part of this survey the Department of Physical Education of the Witwatersrand Technical College, under Dr. Jokl, undertook to examine the state of physical efficiency of school children. The methods outlined above seemed entirely suitable for the purpose. His department carried out over 20,000 individual tests on children between the ages of 5 and 20 years. All races with any considerable representation among our school-going population were examined: English, Afrikaans, Jewish, Bantu, Eurafrican, Indian and Chinese. All were subjected to the three tests referred to above. They were required to run 100 and 600 yards and put the 10 pound iron shot. Care was taken to test only children who had *not* previously received systematic instruction in physical training. By this means it was possible to assess inherent potentialities uncomplicated by the effects of training.

The results of this investigation were reported in detail at the meeting of the Association held last year. They need only be summarized here. An outstanding finding was that the physical potentialities of the various races were strikingly equal. Biological factors had the greatest influence in producing variations in physical efficiency. Environmental factors, of which nutrition was the most important, had less striking influence.

Inadequate dietaries interfered but little with the physical efficiency of young children. At adolescence the glandular changes which occur cause great biological stress clearly brought out in the physical tests on children in poorer schools. Puberty retards the physical performance progress of boys and brings that of girls virtually to an end. As this biological factor is more important in the case of girls it is not surprising that the added stress of malnutrition should show its results more markedly in them. The endurance power of Bantu girls as tested by the 600 yards race reaches its peak at 13 years of age. It then markedly declines until after 18 years it may be lower than that of children aged 6 and 7 years.

This point was also clearly brought out by comparing the results of two schools in George, one attended by relatively well-off girls, the other by girls from poor homes. There was hardly any difference in the physical efficiency between the two groups before adolescence. At adolescence the girls from the economically more satisfactory group strikingly outclasses those from the other group.

An important lesson is to be learned here. At adolescence the strains of physical effort and mal-nourishment are to be avoided. While we can with relative impunity—as far as development of physical performance is concerned—allow of underfeeding of the masses of young children in the country, we are paying dearly in labour efficiency by depriving our adolescents of all races of a proper balanced dietary. Schools would be well-advised too to discourage participation in over-strenuous sport particularly among girls during the period when these important physiological adjustments are being effected. This applies particularly to our poorer schools where nutrition is likely to be deficient.

5. THE SPECIAL SERVICE BATTALION.

The low actual and high potential physical efficiency of young men leaving school was clearly demonstrated by the successful national experiment, the Special Service Battalion. We examined in detail the records of a sample group of 32 of these young men who at the 1935/36 period of economic expansion in South Africa were unable either to obtain or retain employment. The Battalion only recruited men who were " fit," i.e. were able to pass the ordinary army medical examination. They were free from all clinically recognisable defects. They suffered from no ailments and did not have bad teeth or flat feet. Yet employers casting around eagerly for additional labour found them unfit. They were unfit for sustained remunerated work because of low muscular skill, endurance power and strength; because of high susceptibility to "colds," "headache," and "rheumatism," "pain in the back," and "sore throat."

They occupied that dangerous no-mans-land between clinical fitness and industrial unfitness. If left to themselves their lack of initiative would have caused them to sink deeper and deeper into poor-whiteism, as had happened to so many thousands before them.

The Special Service Battalion was established "for the purpose of combating the deteriorating influence of unemployment and of providing discipline and training for unemployed boys and young men." It has been very successful in attaining these objectives. Of over 10,000 European lads between the ages of 17 and 22 who passed through the Battalion more than 90% were placed in satisfactory employment at the end of the six months course of training.

This surely proves that these young men were not economically beyond repair. The money spent on them is coming back manifold to the state: Labour for our industries; removal of ill-health, costly because of expensive medical and hospital services; the incalculably valuable contentment and removal of bitterness against society.

Our sample group of 32 was drawn from one of the first batches of young men to be trained under this scheme. The training programme was considerably improved later as the result of experience. But even this early group derived striking benefit from the course as will be shown.

These lads were examined immediately before the course commenced and thereafter at six-weekly intervals during their training. The measurements taken were of weight, anthropometric, pulse rate (during rest and after standard effort), vital capacity, breath-holding, blood-count, muscular tone, and athletic performance. Details of the remarkable improvement in all of these have been published elsewhere. The physiological, anthropometric, posture and performance tests all revealed a rapid rise from sub-standard to normal levels. The increase in organic efficiency was borne out by improvements in posture, weight, resting pulse rate and in functional reactions such as breath-holding time and the post-exercise decline of vital capacity. The working performance of the recruits as indicated by their three mile running times was significantly improved. At the end of the course their mentally dull appearance had gone and they gave the impression of considerable mental alertness.

All this was effected by a short course the most important feature of which was daily strenuous physical training. Proper feeding doubtless also played an important part since many of the recruits were malnourished at the time of enlistment. The point that cannot be too strongly emphasized is that these young men who were at a physically low level had great potentialities. They were by a relatively inexpensive state measure raised from an industrially unemployable class to one in which they found no difficulty in obtaining employment. The case for a vast state scheme of rehabilitation by means of physical education would appear to need little pleading.

6. Physical Efficiency in the Police Force.

We have seen that it could be demonstrated that among thousands of school children of all races and both sexes the actual physical performance standard was low; but there is clear evidence that with adequate diet and systematic physical education it can be raised significantly. The potential level of physical efficiency among them is high. Their ultimate labour value will therefore be very low unless steps are taken to combat this preventible state of affairs.

That by a relatively small expenditure on the part of the State the physical efficiency of largely unemployable young men can be raised so that they become valuable citizens has been demonstrated by the results of our study of the Special Service Battalion. These young men were fit in the clinical sense, but they were physically not sufficiently skilled, capable of endurance or strong to meet the requirements of the labour market. A six months course of training raised them to this level of fitness.

A third section of the population was selected for examination, namely the men in training at the Pretoria West Police Depot. These are recruited from among youths not only clinically fit but also physically of a high standard. Have these men reached their potential value physically? The answer is given in a sectional paper reported to this

Meeting of the Association. Five troops, of 36 men each, were studied. The men were between 17 and 21 years of age. The course of training extended over four months, the same standard syllabus of physical training being followed in all cases.

I have repeatedly emphasized that an adequate and satisfactory diet is a pre-requisite in any system of physical training. The food in the police camp was satisfactory. Lest it might be suggested that the improved food in the camp might alone have accounted for the striking physical improvement among the recruits coming often from poor homes we took care to eliminate this factor by dividing our subjects into two groups receiving the same food but very different amounts of physical training.

Taken as a whole there is significant improvement in physical condition. There was increase in body weight. chest circumference and in bulk of calf and upper arm muscles at the end of the course. We were satisfied, however, that considerably more improvement could have been obtained by more intense training methods.

This was borne out by comparing a group that had received a total of eighty hours of physical training during the four months with another group who received only thirty hours. The mean weight of the first group increased by over three pounds, whereas that of the second actually dropped over two pounds. The chest girth of the first increased by over an inch, that of the second by only one fifth of an inch. The strengthening of the thigh, calf and upper arm muscles of the first group was indicated by a significant increase in girth in each case; no improvement occurred in these measurements in the second group. The second group who received only two periods of physical training per week are thus seen to have shown no physical improvement.

This finding has an important bearing on our national habits. Strenuous exercise confined to the week-end is likely to do us harm rather than good. The single period of inferior physical training which is all that is received by children in most of even our best schools is patently useless. since the two periods per week of the excellent exercise syllabus followed at the Police Depot were found to be without developmental effect.

The relatively small mean weight increase among our 171 recruits is explained by the fact that some of them were overweight. On them training had the desirable effect of reducing weight. Dividing them into two groups, one in which the individuals weighed 150 lbs. and less, another in which they weighed over 150 lbs. we found that the training had a regulating effect. The first group increased significantly in weight, from a mean of 141.5 lbs. to one of 144.8 lbs. Abdominal measurements reacted similarly; those of the first group increased slightly while those of the second decreased by about the same amount. Thighs also were too thick in the heavy weights and were correspondingly corrected by training. Chest circumference, calves and upper arms increased in both groups as would be expected.

Even recognised athletes benefit from systematic physical training. Of our 171 subjects 35 were good or even outstanding athletes when they joined the police force. Their weight was apparently satisfactory, since they neither gained nor lost. On the other hand their chest girth increased. while that of the abdomen decreased. Muscular measurements of the thigh, calf and upper arm all increased slightly We now realise that there exists a physiological basis of efficiency on which specialised performance must be superimposed. The athlete can improve his performanace if this physiological basis is raised by systematic physical training. Applying this principle to industry, the industrial worker would become more efficient in his particular task if he received such general physical training. His output would increase.

7. PHYSICAL EFFICIENCY AND INTELLIGENCE.*

We have seen that physical efficiency is compounded of three separately measurable factors of skill, endurance and strength. Our aim being the increase of human efficiency as a whole it is necessary also to bear in mind the development of intellectual efficiency. A group of contributors to this symposium have set themselves the question whether a physiological correlation exists between basic intelligence and physical efficiency. They found that no significant correlation exists between general intelligence and mechanical aptitude and that different functions were being measured; basic intelligence and physical efficiency constitute entirely unconnected spheres of human ability. In the production of the citizen satisfactory in the economic sense these two factors have to be developed independently. Neither should be neglected in the child's career.

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* *Cluver, Milne, Suzman, Wilkens—Steyn and Zoke.: S. Afr. Jnl. Med. Sci.* (1942).

A socially important point that emerged from this enquiry was the evidence of absence of any vocational guidance. Little difference was found in the intellectual quality of the material with which the day departments of the technical colleges, the ordinary high schools and the intermediate and junior high schools have to deal. In a high school the range of intelligence quotient was from 142 to 83. A boy with an intelligence quotient as low as 83 can obviously not benefit by the education ordinarily provided in a high school.

8. Diagnostic Value of Regular Physical Training.

If we obtain our objective, the general introduction of physical training for all sections of the population, an additional economically valuable result will be achieved. This emerged from the study by another group of contributors to our symposium. They demonstrated the clinical significance for the discovery of early tuberculosis of fluctuations and deterioration of physical efficiency. Such changes in physical efficiency would be missed unless the individuals concerned were undergoing regular physical training under the care of trained observers.

In the great majority of cases of tuberculosis recognisable clinical signs and symptoms only appear after the disease is well advanced. To obviate the economic loss to the state, because of hospitalisation and removal from the labour sphere, it is essential that diagnosis be made while the individual is still fit and doing his ordinary work. The desirability of preventing the condition becoming "open" and therefore communicable need not be stressed.

Convincing clinical evidence was presented to the effect that active tuberculosis is one of the diseases which always causes marked deterioration of physical efficiency. This evidence if immediately followed up would make it possible to prevent thousands of individuals at present heading for crippling and disabling illness from becoming the victims of much suffering in themselves and a possible danger to their fellows; and they could be so treated that it would not be necessary for their labour to be lost to society.

9. Nutrition.

I do not propose in this address to discuss the importance of adequate food for the youth of the country if we are to develop to a high level of efficiency. I have repeatedly, in addresses to medical, scientific and other bodies, drawn attention to the gross inadequacy of the diet of the greater part of the population of the Union. When I urge now the general introduction of physical education to bring the efficiency of our human material nearer its potential value, I do so on the assumption that the disposal of the evil of malnutrition will be dealt with along with or ahead of a national physical education programme. There is plenty of evidence indicating the positive harm that may be done to malnourished children by excessive muscular effort.

10. CONCLUSION.

The necessity for the attainment of maximum physical efficiency by all sections of the population in time of war is obvious. In time of peace this need might not be so apparent. The large numbers of unemployed persons might suggest that increased physical efficiency might only aggravate a serious social problem. The outcome of the Special Service Battalion experiment suggests that the problem of unemployment might be largely one of unemployability due to remediable inefficiency; untrained men could not be absorbed even at a time of highest industrial activity of the country. I admit that there are other social factors that need to be dealt with in this connection. But I submit that we shall have gone a long way towards breaking the vicious circle of "the unemployed and poor not being able to buy the products of the country" when we have made our people fit to be employed. Vast labours yet await us for which we need the services of every fit individual; reclaiming of malarious areas; construction of roads; irrigation schemes; to mention but a few. Opening up the country by these means would allow of vast growth of all our industries.

We are in this war and we have to win it. Our adversaries whose morals we deplore have advanced far beyond us in organising man power. We can admire their scientific achievement in the mobilisation of human resources without in any way condoning their deplorable morals. If we are to win this war within a reasonable period our productive human material will have to be mobilised to a vastly greater extent than has yet occurred. Our potential efficiency is clearly higher than that of the enemy. Our actual efficiency would appear to be below it to judge from the superficial evidence of reverses during the past two years.

Should the war have the effect of bringing us near to our potential efficiency, we shall have extracted something of value from the ghastly catastrophe that has overtaken mankind.

Expenditure on the attainment of physical efficiency is easily justified. An aeroplane which crashes because of remediable physical inefficiency of the pilot may involve a loss of £50,000 apart from the loss of lives which cannot easily be assessed in terms of money. £50.000 would be sufficient to provide physical training and adequate fitness supervision of very large numbers of our young people

Discipline is necessary in any scheme of physical rehabilitation we may now undertake. Large numbers of young people, because of the low level of vitality to which we have allowed them to degenerate, are unwilling voluntarily to take part in physical training. Many of the lads recruited to the Special Training Battalion would have defaulted in the early stages of their training without a measure of compulsion. But they soon overcame this lack of desire for muscular effort and became enthusiastic participators as the *joie de vivre* developed.

Making our people only twice as efficient as they are at present would have the effect of vastly more than doubling our population. When low grade ore was made payable because of the increased price of gold the value of the mines concerned increased manifold. So also with our present low grade population. Worthless peoples, at present not an asset but a liability, because of the cost of the medical and other charitable services they require, would in large numbers become valuable, working citizens.

The case for the general introduction of a programme of carefully supervised physical education along with one for overcoming malnutrition would appear to require no further elaboration.

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A SURVEY OF THE RECENT PREHISTORY OF SOUTHERN RHODESIA

BY

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Durban.

Presidential Address to Section E, read 1st July, 1941.

INTRODUCTION.

A Survey of the Recent Prehistory of Southern Rhodesia engages us to the consideration of every relic of human activity to be found in that Territory, which can be shown to be subsequent to the close of the Late Stone Age but prior to the Nguni invasions of the early years of last century.

Such a study must of necessity prove to be too large for the space at our disposal, therefore we must rest content with an attempt to correlate rather than to describe the material before us.

To this end we have divided the whole field into a Western and an Eastern Complex. We hold the former to include the Ruins with Terraced Walls, the Zimbabwe Group of Ruins, and the Limpopo Valley Sites; while we assign to the latter, the Inyanga, Niekerk and Penhalonga Ruins, together with the Hill Terraces, Pit Circles and Hill Forts.

We believe that this architectural activity which marks the Recent Prehistoric Period in Southern Rhodesia, was an entirely autochthonous development due to peoples who were well acquainted with the use of metals, pottery, agriculture and animal husbandry, and who were the direct ancestors of our present day Bantu population.

This Bantu Occupation proceeded in three great stages. The first was concerned with people whom their successors called Batonga, and who were ancestral, amongst others to the Sotho tribes. This stage we have termed The Early Rhodesian Period.

Towards the end of the Middle Ages the Shona of the Monomotapa pressed southwards from the Zambesi to form a great wedge which forced the earlier Bantu inhabitants towards the east and the south-west. This stage we have termed the Monomotapa Period.

During the last decade of the 17th century a Roswi chief called Changamire initiated an east to west movement, brought the Empire of the Monomotapa to an end and founded the Mambo dynasty, which was destroyed by the Nguni invasions of about 1830. This stage we have termed the Mambo Period.

These Periods, with the exception of the last, have no real chronological significance, but must be regarded as inundations of peoples who differed but slightly from those into whose territory they intruded, and who not infrequently left large areas untouched by their influence.

SECTION I.

The Western Complex.

Ruins with Terraced Walls.

Mediaeval Rhodesia by D. Randall-MacIver.

Zimbabwe Culture by G. Caton-Thompson.

The most typical ruins of the Western Complex are those with decorated terraced walls, such as Dhlo-Dhlo, Nanatali, Regina, Khami and others; all of which, with the exception of Nanatali, were developed by the successive revetting of the sites, the levels of which were continually raised by the repeated building of platformed huts in the same limited areas. Thus the growth of the walling was dependent on and subservient to the building of the huts, much as in a mollusc the size of the shell is dependent upon the growth of the living animal it contains.

The simplest form of these huts consisted of a circular room with a vertical wall, constructed either of clay, or of clay plastered over a wattle framework, which in turn supported a conical thatched roof. In the more elaborate huts the central room was surrounded by an outer compartment which was subdivided by radial walls. In both types the hut was built on an earthen platform or hut-mound, which varied in height from a foot, to as much as four or five feet.

The plan of this second type of hut served as the model on which some of the principal buildings were erected, for we frequently find that the clay walls of the hut were reproduced by enclosures and radial walls built of stone. This is illustrated very clearly by the plan of Nanatali and also by the Temple at Zimbabwe where the central room is represented by Enclosures No. 1, and the outer compartment with its radial walls by Enclosures Nos. 3, 4, and 5. In short, the stone building was often a hut writ large. (*Fig. 2*).

From this it will be seen, that a rapid filling-in with occupational material, consisting mainly of hut debris, was the normal fate of any enclosed hutting area, and where this did not take place, the lack of debris indicates that the area was only occupied for a short time, or that it was intended to be used as a cattle-pen.

From the analogy of Dzata and other old Venda sites in the Northern Transvaal, we believe that the cattle were penned in enclosures adjacent to the main structure. In other words our ruins of the Western Complex were examples of a village plan with external cattle-pens and thus conformed to the Shona and Venda practice. (Fig. *4*).

We also learn from Dzata that walling was intimately connected with the chief, for the walls in the interior of that place were constructed with stones which had been brought as tribute and seats were contrived in them for his use when giving audience. Besides this, the crests of the walls were decorated with short stone posts as a further mark of his authority. We therefore suggest that the decorated walls of the larger ruins had a similar significance, for their development must have taken several generations to complete during which they were associated with the royal power.

The evolutionary process described above is illustrated by most of the buildings with terraced walls, but at Nanatali we have an example of a building, which although it was on traditional lines, was designed and erected as a complete unit and not by the usual piece-meal methods. (Fig. *1*).

The fundamental unity of all these structures is amply testified by the recurrence in all of them of the majority of the following features:—

(1) The use of decorated walling and terraced walls in the more elaborate buildings
(2) The decoration of the wall crests with stone posts.
(3) The use of constructional timber.
(4) The occurrence of small cylindrical beads of cane glass belonging to the Second Series and similar to those of the Venda ancestral canon.
(5) The occurrence of the Band and Panel polychrome pottery of Class R_3.
(6) A profusion of gold ornaments.
(7) Huts standing on raised platforms or hut mounds.
(8) A village plan in which the cattle-pen was outside the hutting area.

Nor is there any doubt regarding the age of these buildings, for Caton-Thompson found an 18th century glass gin bottle and a Ming bowl at Dhlo-Dhlo, in a position which showed that both were contemporary with the decorated walls. The date thus established confirms Native tradition which attributes them to the Roswi kings of the Mambo dynasty which was founded by Changamire during the last decade of the 17th century.

Zimbabwe.

Great Zimbabwe, by R. N. Hall. Mediaeval Rhodesia, by D. Randall-MacIver.

Zimbabwe Culture, by G. Caton-Thompson.

Zimbabwe: A critical examination of the building methods employed, by J. F. Schofield.

The ruins at Zimbabwe owe their origin to an essentially similar set of circumstances to those which we have described above, but the use of the cramped space at the summit of the Acropolis as a hutting area, made it necessary to abandon the usual practice of terraced construction in favour of one in which the revetment walls were built one over the other, and thus gave rise to the high composite walls; these in turn served as models for the independent western wall of the Acropolis and the girdle walls of the Temple. Further, this great development of dry rubble masonry was made possible by the existence on the site, of unlimited quantities of granite, which under the influence of recurring heat and cold exfoliates into large sheets which are easily convertible into building stone. (Fig. *1*).

It is evident therefore that the unique composite walls of the Acropolis gave rise to the equally unique girdle walls of the Temple and thus it is unnecessary for us to seek analogies for this obviously autochthonous development in the Temple at Marib in Arabia, the Great Wall of China. in Parsee Towers of Silence, nor even in the mosques of some coastal town.

We do not of course suggest that the village unit with its platformed huts and external cattle-pens accounted for all the features of the Temple ruin, although it is clear that its site was used in early times as a hutting area, for the remains of hut platforms have been found in all parts of the ruin, and in places the occupational material has a depth of nine feet.

From an examination of the stonework, we would suggest that Enclosures Nos. 1 and 7 are the earliest buildings to be seen above ground at the present time, and that they formed the double nucleus from which the place developed. (Fig. *2*).

At that stage, the Temple with its two enclosures with their connecting wall (which is now the inner girdle wall), must have been very similar to the Mauch Ruins, but on a smaller scale. The Platform which stands in front of the Cone has its counter part in the West Enclosure of the Mauch, for both formed part of an enclosing wall, and are so similar to the hut mounds of the Maund Ruins, that there can be little doubt but that they too supported huts, which from the importance of the positions which they occupied, could only have been used by important persons. Nor was the Platform the only hut emplacement attached to the inner girdle wall, for a few yards further to the east there are the remains of a platform and steps exactly similar to those which gave access to the raised huts of the Maund.

The door immediately to the east of the Platform was at that time the principal entrance, and as such the two Cones were erected in front of it.

Finally the Girdle Wall was built to surround the whole area. This wall with its monoliths and patterned masonry undoubtedly indicates that the place was a royal enclave, for we have seen similar practices amongst the Roswi and the Venda. Besides all this, the whole plan has so much in common with the lodge or enclosure used by the initiates during the *Kgoma* ceremony of the Pedi, that we cannot doubt but that the Large and the Small Cones, have their analogues in the *Phiri* and *Pishana* cones, which are erected outside the chief entrance to the lodge. While the parallel passage may represent the track of the *Phiri* or mystic hyena, and the position of Enclosure No. 1 is similar to the sleeping quarters of the *mediti*, as the men in charge of the ceremonies are called. (Fig. *3*).

Thus we find at the roots of the Zimbabwe civilization the four factors, which more than any others have moulded the life of the Bantu, namely,—The Chief, The Initiation Ceremony, The Cattle and The Hut. Further we find these associated with traits which we can recognise as being characteristic of the Pedi and/or Venda cultural practice.

The earliest notices we have regarding Zimbabwe are contained in the well known passages of De Goes and De

Barros, from which it has been assumed that these writers were referring to the buildings as we have them to-day, but this is far from being the case, for Mauch who visited the ruins in 1871, recorded that the doorways had been constructed with wooden lintels, of which traces were seen by Bent twenty years later, and finally considerable remains of similar lintels were found by Douslin in 1914 while he was engaged in clearing the entrance to the Acropolis. Since wooden lintels spanning openings in rubble walls must suffer alternating wet and dry periods, it is evident that their life under such conditions should be measured in decades rather than in centuries. It is therefore impossible to believe that the large independent walls in which the lintels occurred had already been built in the beginning of the 16th century, and we suggest that the travellers' tales upon which the early Portuguese reports were based, referred to the composite walls of the Acropolis, and since even at that date the buildings were considered to be old, it is probable that these composite walls had been erected during the Early Rhodesian Period which preceeded the advent of the Monomotapa.

Unfortunately we are unable to assign any of the walls at Zimbabwe to the Monomotapa Period with any degree of certainty, for rubble walls have few distinctive features and we have not been able to make out definite associations between the R_2 pottery which characterised that Period and any type of walling, although it is not improbable that some of the internal walls of the Temple should be credited to it.

The late date which we have suggested for the larger walls accords fully with the use that was made of patterned stone-work and stone posts in their decoration, and of timber in their construction, for as we have seen, all these features are characteristic of the Mambo Period which flourished during the 18th century.

A similar date is also indicated by the quantities of wrought gold which was found near the surface and in "ancient" burials when the place was first explored. All of this gold was in the form of plates, tacks, bangles and beads, it was therefore similar in every way to the gold ware found in a great hoard at Dhlo-Dhlo by Messrs. Neal and Leach in 1895, and which was dated by R. N. Hall, from the European articles with which it was associated, as belonging to the middle years of the 18th century.

A number of fragments of imported china and glass dating from the 13th to the 15th centuries have been found from time to time, but unfortunately the stratigraphy of only two of them has been recorded. In one case pieces of a Sung Celadon vase were found in the platform of a comparatively modern hut, (1, p. 67), and in the other the china was too indefinite for identification.

The only other datable objects we have are the glass beads, and as it was upon the evidence from this source that Caton-Thompson based her dating of Zimbabwe, we cannot do better than describe her excavation at Test A.3, from which she derived her most decisive results.

This excavation was carried out in a terrace enclosure on the northern face of the Acropolis Hill, at a distance of 83 feet from the West Wall. For a depth of 17 feet 6 inches terrace infilling and a few obscure walls were encountered; below this there was a pavement of granite slabs resting on a midden deposit which had a vertical depth of 6 feet and rested in its turn on the bed-rock. This pavement is of considerable importance, for it divided and sealed off the midden, from the terrace infilling and the structures which it contained.

The archaeological material recovered from the infilling consisted of iron tools and weapons, Class B and B_1 pottery, spirally wound bangles of flat bronze wire, a biconical bead of light blue wound glass and, on the pavement itself, an oblate bead of pale blue glass.

The midden yielded 20 pieces of Class A pottery, 235 sherds of Class B pottery, a few sherds of a similar ware, iron blades, iron wire and 80 glass beads which Caton-Thompson classified as follows:

Type.	No.	Description.	Remarks.
1.	23.	Black cylinders.	
	11.	Black oblates.	
2a.	2.	Opaque lemon yellow cylinders.	Affinities with yellow beads from Pemba, Tangal and South Indian sites, dated at about the 8th century.
	1.	Opaque lemon yellow oblate.	
4a.	14.	Opaque sky blue oblates.	
4c.	10.	Transparent blue cylinders.	The *Maḓi* of the Venda.
4d.	1.	Transparent royal blue oblate.	
5a.	6.	Opaque green oblates.	
6a.	1.	Opaque Indian red cylinder.	South Indian and Malay affinities of 8th to 9th centuries. The *Mukuvhibvu* of the Venda.
6b.	1.	Indian red over clear green base cylinder.	Popular down to the 18th century.
8a.	8.	Opaque white oblates	

In addition to this we are informed that similar beads to those of blue and green glass are found in Southern India and Malaya, where they are dated to the first milennium A.D.

Thus we have before us a collection of beads of which some are related to 8th, 9th and 11th century beads from India and Malaya, others are related to, if not identical with two varieties of the Venda Ancestral Beads, of which many thousands are in daily use, while another, the 6b, is of an 18th century date under most circumstances.

In Caton-Thompson's opinion the Malay and Indian associations outweighed all the other considerations and led her to date the whole collection, and from it, the beginnings of the occupation of Zimbabwe to the 9th or 10th centuries A.D.

Our Author rightly emphasized the importance of the occurrence of Venda Ancestral Beads in this and similar deposits at Zimbabwe. This relationship was in fact even more pronounced that she realised, for although the light blue cylinders of 4c are nearer to the light blue beads from Bambandyanalo than they are to the *Madi*, two other types, namely the black and the lemon-yellow cylinders are respectively similar to, if not identical with the *Tshinovhe* and the *Mushosho*, while the *Sodzi* may be worn down examples of the black oblates. Thus out of the 80 beads recovered in this excavation, no less than 47 are related to the beads of the Venda Ancestral Canon.

Further it must be conceded that beads must have been imported in vast quantities for centuries before their value had fallen to such an extent, that in an inland centre, they could be swept into the midden in considerable numbers. It is therefore evident that the time limit set by the establishment of the Arab towns on the East Coast does not admit of the importation of Indian and Malayan beads in sufficient quantities, during the 8th, 9th and 10th centuries, to meet the facts of the case.

If this collection were to be judged by the standard which we have suggested for the beads from the Limpopo Valley Sites, then we should have no hesitation in ascribing the whole of it to the period between the 16th and the early 19th centuries, for all three of our Series are represented, the First by the oblates; with the exception of the white beads, the Second by the cylinders, with the exception of type 6b, and the Third, by the white oblates and the Indian red over the clear green base. (2, p. 368).

Although these views may seem to be revolutionary, we must remember that Caton-Thompson based her views on similarities between the Zimbabwe beads and beads from very distant centres, for no actual proof was brought forward that any beads had in fact been imported into South Africa from India and Malaya during the 8th and 9th centuries. When we turn to her observations on the structures which were superimposed upon the pavement which sealed the midden, we find that they tell a completely different story. In discussing the relative ages of these structures, she says:—

> "it seems likely that the north-west ascent was laid out at this same time: (as the building of these structures) if so, we are dealing with a period when the wall of the 'Western Temple' was already built, for this path skirts its base and enters the fortress to the north" (1, p. 80).

But as we have already seen, the wooden lintels of the entrance which passes under this wall, were found by Douslin in 1914 (3). Now there can be no doubt but that these lintels were contemporary with the work which they supported, and there is also no doubt but that, in such a position, they could not have lasted more than a century or so. It seems likely therefore that the A.3 midden was not actually sealed up before the latter part of the 18th, or the early part of the 19th century, which is entirely in accordance with our dating of the beads.

The only bead which resembles any of the Arab beads from the coastal sites, is the bicone of light blue wound glass which was found in the infilling, if it is indeed one of those beads, it may be dated to the period subsequent to the revival of the Arab power on the East Coast which took place towards the end of the 17th century.

The relationship between the Venda Ancestral Beads, and those from our archaeological sites, will be discussed more fully in a subsequent Section.

The chronological sequence which we have suggested derives powerful support from the study of the three principal classes of pottery which have been found on the site, which we have styled,—

> Class R_1, which is to be equated with Caton-Thompson's Class A. It has been found at a number of places in the Valley of the Ruins, where its stratigraphy indicates, in our opinion, that it anti-dates the existing buildings, while from its occurrence in Test A.3, we judge that it also anti-dates the erection of the West Wall of the Acropolis and it may therefore be contemporary.

in part at least, with the composite walls. As will be seen later, this pottery can be correlated with the Early Rhodesian Period.

Class R$_2$, which is to be equated with Caton-Thompson's Class B$_2$. We believe that this pottery was in use during the Monomotapa Period. In the Maund Ruins Caton-Thompson found it most frequently above the "cement" floors and very generally in the other ruins. With it there was a banded ware which she called Class B$_1$, and which has only been recorded from one other site.

Class R$_3$ is the band-and-panel polychrome pottery which is very definitely associated with the Mambo Period. Caton-Thompson only recognised six sherds of this ware, which she termed Class D. But it is evident from an examination of her material, that she included much of it, particularly the undecorated examples, with her Class B.

The Limpopo Valley Sites.

Mapungubwe, Ancient Bantu Civilization on the Limpopo, by Leo Fouche.

Mapungubwe has been described with such a wealth of detail by Dr. Leo Fouche, that we need deal with only one aspect of the whole subject, namely that of the original inhabitants of the place.

An examination of the pottery from the Limpopo Valley sites shows that it included two main groups, of which one, Category M$_1$, is well known as Caton-Thompson's Class B$_2$ and/or our Class R$_2$, while the other, Category M$_2$, had never been recorded before, but appears to be related to modern Tswana or Basuto wares, and possibly to Luba pottery from the eastern area of Northern Rhodesia.

It came therefore as a surprise to learn from Dr. A. Galloway's analysis of the skeletal remains, that both groups of pottery were made by people whose physical type approximated closely to that of the Hottentots, and it is needless to state that this discovery gave rise to the suggestion that the whole of the civilization disclosed at Mapungubwe was due to the ancestors of those people.

This suggestion is open to the following objections,—

(a) The Hottentot physical type is associated with no less than five distinct material cultures.

  (i) a Middle Stone Age industry at Zitzikama;
  (ii) a Late Stone Age industry on the Natal Coast;
  (iii) the classical Hottentot culture at the Oakhurst Shelter;
  (iv) two varieties of Bantu culture at the Limpopo Valley sites; and
  (v) the quasi-European culture of the present-day Hottentots.

(b) The material culture found on the Limpopo Valley sites is shared at the present time by a vast concourse of Bantu peoples, who, as far as we know, have never enjoyed any other form of culture.

(c) A traditional knowledge of Mapungubwe and its wealth had been handed down amongst the local Natives, and was still sufficiently exact for Mowena to guide the prospectors to the place in 1932.

(d) All the remains of cattle found at Mapungubwe belonged to the short-horned type, and not to the long-horned Africander breed of the Hottentots.

It is therefore probable that we have before us an example of cultural transference, in which a people of a predominantly Hottentot physical type adopted a material culture which was predominantly Bantu.

This suggestion of cultural transference derives support from Fernandes, who about 1515 encountered a light skinned steatopygous people called Rabos from the kingdom of Mombara, on the banks of a large river, which was probably the Hunyani. These people, he tells us, traded gold and copper with the merchants of the Monomotapa. (4, p. 24).

The Monomotapa was the greatest potentate in all the land, for his power extended to the coast, to the south-west he was bounded by Batongwa and we find the same name in the north-east of his dominions, while we know from other sources that Batonga people occupied the Zambesi valley.

Thus it would appear that in the early 16th century the Shona influx under the Monomotapa had penetrated deeply into the midlands of Mashonaland and was displacing the original inhabitants, whom the new comers called Batonga. that is subject peoples, towards the south-west and north-east. The first of these may have been the ancestors of the Sotho tribes of the Northern Transvaal, while those who were driven eastwards may have given rise to the Venda and it is interesting to find that their legends recount the ancient glories of Matongoni, which may well have been the town of Otonga on the Zambesi where there was "a great fair patronised by Natives and Arabs." (5, p. ?), (6, p. 121).

In this southward thrust the Shona may have absorbed tribes of Boskopoid or Hottentot people, much as the Xosa incorporated the Gonaqua in their social system two hundred years later.

SECTION II.

The Eastern Complex.

The Niekerk, Inyanga and Penhalonga Ruins.

Mediaeval Rhodesia, by D. Randall-MacIver.

The Penhalonga Ruins, by A. York Mason (20).

The archaeological remains from these areas may be classified as:—

Contour or Terrace Walls, Pit Circles, and
Water Courses, Forts.

It is unnecessary for us to canvass the excellent descriptions given by our Authors. There is however a curious divergence between them regarding the construction of the Pit Circles, for while MacIver states clearly that the surrounding platform was heaped up round the central enclosure, the floor of which was at ground level. Mason is equally insistent that the enclosure was sunk, in part at least, into the ground. Regarding this, Mr. K. Robinson has informed the writer that his observations agree with MacIver rather than with Mason, and it is therefore clear that both reported correctly what they saw.

The elaborate arrangements made for the drainage of the central pit or enclosure, show that it was intended to be used as a cattle-pen. Thus explained, the whole lay-out of the Pit Circle is seen to be identical with a village plan (such as that used by the Zulu), in which the cattle-pen occupies a central position. Indeed the fundamental difference between a Pit Circle and a Zulu kraal lies in the fact that the huts of the former required a hut-mound or platform for their construction, while those of the latter, being made of thatch, required no such provision, and are built on the natural ground-level. We must therefore regard the "platform" as being a continuous hut-mound formed round the central pit or cattle-pen. We would also suggest that the development from the isolated hut-mound to the continuous platform gave rise to the tunnel entrance and the drain.

Cattle small enough to pass through these tunnels were seen by Livingstone on the Zambesi, where he found that they were kept as pets. According to Native Tradition, they were being imported into the country from the Zambesi valley during the last century. (7).

The walls of the forts are frequently provided with a banquette and are loop-holed. The entrances had a width of 20 inches with a height of about 40 inches, and were spanned with large slabs of stone, being altogether similar in construction to the entrances of the Pit Circles. In the interior there are always the remains of huts altogether identical with those of the Pit Circles. In one of these forts at Niekerk, MacIver found that a wooden bar for closing the entrance, was still intact, although it had been built in position when the place was erected.

The only objects recovered from the forts have been a few beads, which were probably made in Europe about the beginning of last century, and domestic pottery, similar to that still used in the district.

Since it would appear that fire-arms were not in common use in this part of South Africa before the beginning of the last century, the loop-holed walls of the forts indicate that they were erected about that date, which conforms with the evidence of the beads, while the similarity of the structural details show that there is no great disparity in age between the forts and the pit circles.

The Water Courses also show no signs of great antiquity for without either paving or revetting it is evident that they could not last very long. Similar water courses are made at the present time by the Wachagga, a Bantu people living on the slopes of Kilimanjaro.

SECTION III.

A SURVEY OF THE POTTERY OF SOUTHERN RHODESIA.

Mapungubwe. Ancient Bantu Civilization on the Limpopo. Pottery Section.

Pottery from the Salisbury District, Southern Rhodesia, by J. F. Schofield and P. Stapleton. (8).

The Recent Archaeology of Gokomere, Southern Rhodesia, by T. Gardner, J. F. Schofield, L. H. Wells (9).

This survey will deal only with the three classes of pottery which have been found on a number of sites, and of which the sequence has been definitely established.

Class R_1 Pottery (Fig. 5).

The earliest pottery of which we have a good working knowledge was made in a number of types, which included bowls, shouldered pots and spherical pots or bowls. The fabric was coarse, and the surface was coloured brown or black, with a matt or burnished surface; this applies particularly to the interior of the bowls, which were finished with great care.

The ware is distinguished by the treatment of the projecting rim-band, which in bowls and spherical pots was left plain, but in the shouldered pots was almost invariably decorated with comb, bangle impressions, or incisions, placed diagonally. Below the rim-band, the neck or the corresponding part of the vessel was surrounded with parallel lines, which were often made with a comb.

The contour of many of the finer vessels was carinated, and that of the more ordinary pots was subangular. The ridge of the carination was marked by a line of impressions, and even when it was not present, the corresponding part of the pot was often decorated in a similar manner.

This pottery has been found directly superimposed on strata containing Wilton artifacts at Gokomere and Bambata, and mixed with such material at the Salisbury Commonage Sites. It has been described from Zimbabwe, Dhlo-Dhlo, Madiliyanga Rock Shelter, Que-Que, Echos Farm near Salisbury, Maonza Cave near Umtali, at Parma and at the Arcturus Mine. (8).

From its similarity to pottery from Aasvoëlkop near Johannesburg it has been suggested that this ware is the ancestral pottery of the Sotho people, before they crossed the Limpopo on their southward migration, which, perhaps, took place during the 15th century.

It is also clear, from such sites as Gokomere, that it continued to be made in that locality, until comparatively modern times. (9)

This pottery was termed Class A by Caton-Thompson, but we propose to use the symbol R_1 to include it and all related pottery industries.

Contemporary with the earliest days of Class R_1 pottery there were a number of more or less distantly related traditions of which several have been included under Category M_3 at Mapungubwe.

At Mumbwa in Northern Rhodesia a ware has been described of which the typical vessel has a tall conical neck, decorated with comb marks and a projecting convex rim-band; which we may regard as being a distant relative.

At Bambata a very different but contemporary pottery has been found. It is characterised by a lavish decoration of point marks and parallel lines, while the lips have crenulated edges. Spherical bowls with decorated spouts were made, but the most typical vessel seems to have been a shallow dish with almost vertical sides.

Class R_2 Pottery. (Fig. 6). This is a fine and well made ware usually finished with a burnished black, grey or graphite surface, the characteristic types were the shallow bowl and tall necked pot which were frequently beautifully designed and decorated.

At Mapungubwe, Zimbabwe, M'Telegwa and Macardon Claims near Gwanda it has been found in association with gold. At Zimbabwe it was contemporary with the building of the finest stone-work, which was altogether absent at Mapungubwe.

The associations of this pottery may be classified as follows:
At Zimbabwe, Mapungubwe, M'Telegwa and Macardon Claims, it has been found with wrought gold.
At Zimbabwe it was contemporary with the building of the finest walls, at Sibsey with poor walls and at Mapungubwe with revetments only.
At Zimbabwe its makers belonged to a Negroid stock, at Mapungubwe, they were certainly Boskopoids.
At Zimbabwe it succeeded the R_1 wares and was contemporary with the ribbed pottery which Caton-Thompson called B_1 of which the only other known specimen was found in the Indarama Mine at Que-Que.
At Mapungubwe it was associated with a completely different ware, called M_2, which was contemporary with Class R_1 pottery, and also with a number of imported wares all of which have R_1 traits.

All things considered we believe that this pottery was made by people who had a Shona type of culture, and who, under the Monomotapa, were paramount in Southern Rhodesia during the 15th, 16th and 17th centuries.

The occurrence of this pottery both with and also apart from well developed stone walling, indicates in our opinion that stone buildings have a geological rather than an ethnological significance.

Class R_3 Pottery (Fig. 7).

The pottery of the Roswi-Venda peoples. This ware was decorated with bands forming squares, triangles or chevrons. The panels between the bands were filled in with stippling or hatching. The surface was coloured red, buff, dead black, and also polished with graphite. The lines of the decoration were generally incised on the wet clay, but sometimes they were engraved on the burnt pot.

The types of vessels made include spherical pots, shouldered pots and pots with short vertical necks. These last are found with the neck divided into several shallow horizontal flutes.

In Southern Rhodesia this pottery can be correlated with the Mambo Period, that is, from about 1700 to about 1830.

It has been found associated with gold and beads of the Second Series, and on the following sites: Dhlo-Dhlo, Nanatali, Zimbabwe, Khami, Dzata, Haddon and Maryland. At Zimbabwe Caton-Thompson called it Class D pottery.

It is probable that each of these principal classes of pottery was introduced into the country as a full-blown entity, and was not developed locally.

SECTION IV.

A Survey of the Prehistoric Beads of Southern Rhodesia.

Beads of the Water, by C. van Riet Lowe. (10).
A Preliminary Study of the Prehistoric Beads of the Northern Transvaal and Natal, by J. F. Schofield, (16).

The Arab Beads. It would be reasonable to suppose that since glass beads were well-known in Egypt and Arabia during the early Mediaeval Period, they would form part of the stock of the Arab traders who opened up the trade in gold and ivory at Sofala, probably early in the 9th century. That beads were actually in use at the Arab ports on the East Coast is shown by the quantities which are still to be found on the seashore at most of these places.

These beads fall into three main classes:

(1) Large irregular cylinders of cane glass, coloured Indian red, blue, green and yellow, measuring about 10 x 8 mm.

(2) Beads of pressed glass, discs, measuring 4 x 10 mm, and coloured red, black, and yellow, and spheres of the same colours, about 12 mm. in diameter, and frequently decorated.

(3) Biconical beads of wound glass, black, red, green, yellow and blue, measuring about 5 x 5 mm.

It is tempting to regard these classes as representing the periods of Arab ascendancy on the East Coast, Class (1) being the beads used before the Portuguese Conquest.

This is very probable because early in the 16th century red beads " as big as the tip of a finger " were being used at Sofala. This describes the red beads of Class (1) so accurately, that it is probable that they are one and the same. In addition to this Mrs. B. Thompson of Messina has found these very beads there.

It is suggested that Classes (2) and (3), of which only stray examples have been found in the Rhodesian ruins, were used after the Portuguese Conquest.

Portuguese Beads. After the Portuguese Conquest, our information regarding the beads used in trade is much more precise and we are informed that the coloured clay beads from Negapatam in India were the principal beads used; and we can infer that this continued to be the case until that place was captured by the Dutch in 1660.

Unfortunately, with the doubtful exception of some of the beads found by MacIver at Dhlo-Dhlo, and a few others at Cathkin Park, none of these clay beads have been found on any of our archaeological sites.

Beads of the First Series. The Portuguese also imported small glass beads from Flanders, which may be the small, brightly coloured oblates which have been found at bed-rock at Zimbabwe and Mapungubwe. It is these beads which form our First Series, and with them we include the small black beads which are called *sodzi* by the Venda. All of these beads must therefore be dated as being later than the beginning of the 16th century.

Beads of the Second Series. More or less contemporary with the First Series are the small cylinders of cane glass, black, light blue, lemon yellow and Indian red, which have been found at bed-rock at Zimbabwe and Mapungubwe, and are identical with some of the oldest beads of the Venda ancestral canon. Beck's suggestion that those beads were imported from India and Malaya during the 8th or 9th centuries A.D. is unlikely for the following reasons:—

(1) The only way in which beads could be brought from India to South Africa during those centuries was in the dhows of the Arab merchants, and it is, therefore, very curious to find not only that the Arabs' own beads are absent, except as strays, from the Rhodesian ruins, but also that the small cylinders are not found on the purely Arab sites.

(2) Furthermore, we know that the Venda did not come on the Rhodesian scene before the end of the 17th century. We must, therefore, presume a separate importation of these beads to their 9th century ancestral home, wherever that may have been, and since the Venda do not recognise the old Arab

beads as being part of their canon, this importation must have been carried on independently of the only channel by which the beads could have been brought from their place of origin. Apart from this, it is most unlikely that glass beads could survive a thousand years of daily use by the Venda in the numbers in which we find them to-day.

Professor C. van Riet Lowe has made a special study of the Venda beads and has classified their *Maḓi* beads as follows:—

V.1. *Vhulungu ha Maḓi*: pale bluish green.

V.2. *Vhulungu ha Maḓi*: pale blue.

V.3. *Vhulungu ha Maḓi Lutumbe lwa Maḓi*: turquoise.

V.4. *Vhulungu ha Maḓi Mafhe*: lapis lazuli. (10).

Dr. W. E. Schilz has shown by means of Spectroscopic Analysis that of these, V.1. is made of an identical glass to that of the small light blue cylinders and the large cylindrical beads from Mapungubwe and Bambandyanalo, and that V.2 and V.4 belong to the same group, V.2 having more copper and less cobalt than V.4. These beads are respectively similar in colour with the light and dark blue cylinders from Dhlo-Dhlo which can be dated definitely to the beginning of the 18th century.

V.3 was made from an entirely different glass which contains antimony. It therefore probably had a European origin and must be dated as being subsequent to the beginning of the 16th century.

Since the *Maḓi* are the rarest and presumably the earliest of the Venda ancestral beads it is evident that a later date must be accepted for the remainder of their Canon and for analogous types wherever they occur. Therefore Caton-Thompson's beads from the bed-rock at Zimbabwe Acropolis (Test A.3) and elsewhere, the beads from Mapungubwe and Bambandyanalo, can be no earlier, although they may be considerably later than the beginning of the 16th century.

With this Series we should probably include the large Indian red on transparent green glass cylinders and the crackled white and similar beads, and also the large cylindrical beads from Mapungubwe which were made from the smaller beads of this Series.

Beads of the Third Series. This Series belongs pre-eminently to the *Lifiqane*, and only these beads have been found in the loop-holed Hill Forts. Its characteristic beads are the large beads of wound glass, Indian red cylinders, the blue hexagonals and annulars, whites, greys, pinks, red-on-white, blue-on-white, Indian-red-on-transparent-green and striped beads. The beads were all probably made in Europe and are to be dated as being subsequent to 1800, and the Series gradually merges into the modern trade beads.

SECTION V.

A SURVEY OF THE ANCIENT WORKINGS OF SOUTHERN RHODESIA.

Some Observations on Ancient Mine Workings in the Transvaal, by T. G. Trevor. (17).

Ancient Tin Mines of the Transvaal, by Max Baumann, (18).

An Engineer's Notes on Old Mine-workings of Transvaal and Rhodesia, by F. E. B. Fripp. (19).

The Ancient Workings of South-East Africa, by J. F. Schofield. *Nada* (1925).

Old mine-workings which anti-date the European Occupation have been found over a large part of the Central Plateau of South Africa between the Zambesi Valley and the latitude of Pretoria. Their presence is usually indicated by a succession of conical depressions which mark the position of the old shafts, the heads of which in the course of time have weathered down and provided favourable foot-holds for the growth of dense bush or timber. Round these depressions traces of dumps may be found, which however, are generally quite free from any trace of the mineral which has been sought by the old miners.

In various parts of this vast area a large number of different minerals have been exploited of which the principal were iron, copper, tin, graphite, various ochres, and micacious iron ore which was probably used as a pigment. Gold on the other hand had only been mined extensively north of the Limpopo, for in the Transvaal only one undoubted ancient working for gold has been discovered.

With the exception of gold, which was washed from alluvium as well as being mined from the reef, the methods used were everywhere identical,—The out-crop of the mineral was quarried out and the lode was followed for some distance underground. When the rock was hard, recourse was always had to the practice of fire-setting. Pieces of wood were piled against the reef and fired. When the rock was hot enough, it was shattered by having water thrown on to it. The broken reef was then prized out with steel or iron gads which were driven in by unhafted stone hammers. This process was carried on until the stope had to be abandoned, probably through lack of ventilation for the fires. When this happened, a shaft was sunk down to the reef a little further on, the same method of fire-setting being used as in the stopes. The reef at the foot of the shaft was then worked out in both directions, until the stopes became so long that they had to be abandoned in their turn.

The sinking of shafts and the stoping out of the reef was carried on time after time until either the reef became exhausted, water level was reached, or the shaft became unmanageably deep, when the working had to be finally abandoned; but prior to this being done, it was carefully filled in with waste material. This in-filling is a striking feature of almost every old working which has been examined, so much so that in the few examples in which it is not present, it may be assumed that the miners must have left their work through some unforeseen emergency.

In contrast to their primitive appliances, the old miners showed great skill in leaving proper pillars, or in supporting the hanging walls of their stopes with wooden struts, and also in cleaning every trace of ore from the lodes.

It seems likely that the ore was concentrated in the workings and then carried in large pots or bark buckets to the surface, where it was roasted and ground to powder with large stone mullers, which weighed up to 100 lbs. The powder was then washed or winnowed, and in the case of gold, tin, and perhaps copper, it was smelted in a small clay crucible in a furnace with clay sides. As clay tuyeres have been found on all smelting sites, it is evident that the draft was provided by bellows similar to those used by modern Natives.

Iron was smelted in two forms of furnace, the one was built up of clay above the surface of the ground, as is the case amongst the Venda, the Shona and the Illa tribes of

Northern Rhodesia; the other was sunk into the ground in a similar manner to that formerly used by the Zulu.

The shape of the ingots into which the metal was cast varied in different localities. In the north and also at Zimbabwe copper was cast into ingots shaped like a St. Andrew's cross, and weighing about 7 lbs. In the Messina district ingots shaped like a top hat with nipple-like projections in the crown were made. At Palabora the ingots were pipe-shaped, with a stem about ½ inch in diameter and two feet in length. Tin was cast into small hemispherical ingots which were sometimes pierced through the centre.

The only recorded object from an Ancient Working which can be exactly dated is a silver sixpenny piece of Queen Elizabeth, dated 1572, which was found in a filled-in stope in the Quagga mine at Odzi.

Steel or iron gads have been found in many workings, they vary from 6 to 18 inches in length, with a square or a slightly dumb-bell-shaped section. The larger examples were driven with stone hammers, but the smaller were usually pointed at each end and were evidently intended to be set in a knobbed stick and used like a Native axe or adze. A wooden haft for one of these gads has been recorded by Baumann from the South End Lode at Rooiberg.

Hammer stones have also been found in large numbers. They were roughly cubical or spherical in shape and were frequently natural dolerite pebbles weighing about 3 lbs., hollowed and facetted by long use.

Selous mentions the finding of a bark bucket and rope at the bottom of a shaft which was 120 feet deep near the Umsweswi River. (11)

Pottery, which is similar to wares known to have been made by different Bantu peoples, has been found in several workings. Caton-Thompson has illustrated a pot from an old working in the Indarama Mine at Que-Que, which is similar to her Class B_1 pottery from Zimbabwe. Baumann has illustrated another pot from the Rooiberg tin mines which he says "resembles in all respects a Basuto cooking pot." There are in the Museum of the Archaeological Bureau, two little decorated pots from the same mines, which resemble Class R_1 pottery of the type which has been found in the Arcturus workings near Salisbury.

A number of steel bangles were found in the Gaika mine at Que-Que. In all probability they belonged to a woman miner who was a votary of one of the Madjukwa cults which seek the protection and assistance of a Shavi spirit.

It is a noteworthy fact that no sort of a lamp has ever been found in an Ancient Working. It is therefore probable that the old miners, like those of Vendaland, made torches from euphorbia leaves or used cassia pods as candles. (22)

Only seven of the skeletons found in the old workings have been critically examined, and all were shown to have features which are associated with the Bantu, of these skeletons five belonged to women or young girls. Doubtless women and children were employed in the mines, because they are smaller than men and it was thus possible to reduce the size of the stopes and shafts to a minimum. It is interesting to note that before the passing of the first Mines' Act in 1842 similar practices obtained in the coal mines of Great Britain.

Wherever archaeological work has been carried out on any ancient ruin in Southern Rhodesia, quantities of iron implements, copper and/or bronze bangles have come to light. We have commented elsewhere upon the vast quantities of gold which were exported during the Portuguese Occupation. To these we must add the riches of the "ancient" burials and other gold looted by Neal and others, the gold of Mapungubwe, and perhaps, many another hidden treasure. We have also shown that all datable objects found with this gold belong to the 16th, 17th or 18th centuries, it is therefore reasonable to suppose that the gold with which they were associated was produced during the same centuries.

The earliest reference to the gold trade, and consequently to gold mining in South Africa, is contained in a quotation from the Chronicle of Kilwa by de Barros (12, vi, 273) which relates to the founding of Sofala, probably early in the 10th century, and states that before "that time it (gold and ivory) had never been exported from that part of the coast of Sofala." We are justified in supposing that this gold was obtained from alluvial workings because the word *dahabo* (c.f. Chicaranga, *abo*) is obviously derived from the Arabic *dahab*, and was used exclusively for alluvial gold during the 16th century (12, vii, 218). In the same connection Dos Santos describes the mining at depth for gold and states that the gold thus won was called *matuca*. A little later, Barratto made an even more detailed description of gold mining as it was being carried on during the 17th century (12, iii, 489).

Dos Santos also refers to copper mining and tells us that the copper was melted and cast in holes made in the earth (12, vii, 380 and 270). The same practice was in vogue amongst the Venda and is also recorded by Moffat (12).

When Vasco da Gama visited the mouth of the Sabi River in 1498, he found the Natives had numerous copper ornaments and iron daggers with hilts of tin, and his chronicler related " there seemed to be an abundance of copper and tin in the country " (12, v, 362).

Moreover in the terms of the treaty which was made early in the 17th century (either 1607 or 1616), the Monomotapa agreed to surrender to the King of Portugal " all his mines of gold, silver, copper, tin, iron and lead " (12, iii, 368). That these mines were identical with our "Ancient Workings" is indicated by the practice which the "Kaffirs" had of filling in their mines in order to conceal them, which was the subject of bitter complaints from the Portuguese adventurers.

After the wane of the Portuguese influence, notices of the mines and their products becomes more scanty. In 1723, Jan van der Capelle, an official of the Dutch East India Coy., stationed at Delagoa Bay, reported that the Natives had recently brought copper and tin from the countries of Machicosje and Paraotte for barter at the fort. He also stated that all the people of the interior used the tin for alloying with copper in the making of necklets and bracelets (12, i, 413).

Early last century Lichtenstein found bronze rings in use amongst the Tswana which were composed of 93% copper and 7% tin. In 1826 Moffat came across a Huruthse smith near Marokweng, who showed him how he melted down tin and copper, cast the bronze into ingots and then with the aid of an iron draw-plate, made bronze wire. (14)

Towards the end of the century, Selous recorded that the Matabele whom he met during his earlier expeditions, insisted that when they invaded Rhodesia they found the Natives working gold in the *amaguti* or deep holes on the quartz reef. In 1884 he visited the head of one of these filled-in shafts, where he found that the whole process of burning and crushing the quartz had been carried on. On clearing out the shaft, part of the roof was found to be supported with mopani poles; which showed no signs of any great age for they still had the bark on them. They had been felled by narrow-bladed axes similar to those used by the modern Natives. (11)

In 1872, Thomas Baines found gold mining in progress in the Lomagundi district (15). He also met Natives near Hartley who told him that their fathers had made some old workings which he had seen, and that they used to sell the gold which they obtained to white men, who lived in a house the ruins of which were still standing.

There is no need to emphasize the blow which was dealt to South African Native civilization by the *Lifiqane*. In Rhodesia, Lobengula did his utmost to discourage gold mining by the Natives, because he feared that, if the mineral wealth of the country became known, it would speedily be occupied by Europeans. In Gazaland, for the same reason, the Native miners were exterminated by the Shangaans.

From the foregoing we believe that the following conclusions are justified:

(1) Since alluvial gold workings are always the first to be exploited, and since in early times the word *Dahab* and its derivatives were used to describe alluvial gold, we believe that this primary exploitation was commenced by the Arabs, probably during the Early Rhodesian and Monomotapa Periods.

(2) That mining from the reef was a secondary development, and the early use of the word *Matuca* to describe the gold from this source indicates that this exploitation was carried on by Bantu as recorded by Barratto.

(3) That the work was continued throughout the Monomotapa and the Mambo Periods, is demonstrated
   i. by the Historical Records,
   ii. by the discovery of hoards of worked gold associated with pottery, beads and other objects, which are known to be of a 16th, 17th or an 18th century date, and
   iii. by the fact that gold was only mined in those regions which came under the influence of the Arabs and/or the Portuguese.

(4) The uniformity of the mining practice found in the South African workings, whatever mineral was sought, indicates that they were all made by a people who enjoyed a similar cultural standard. As the only primitive metal-working folk with a uniform culture to have occupied the territory, are the Bantu, and since this

mining practice persisted down to recent times, it is therefore clear that the workings must be attributed to them.

(5) The mining of gold in a comparatively small section of the whole area in which copper and iron had been sought, suggests that a knowledge of those two metals anti-dates the knowledge of gold in South Africa, and also that we may regard the use of copper and iron as forming part of the cultural inheritance of the Bantu tribes when they first occupied the territory to the south of the Zambesi.

(6) Mining on a large scale only ceased when the last phase of the Zimbabwe Civilization was disrupted by the Nguni invasions of Southern Rhodesia during the third decade of the 19th century.

SECTION VI.

A SUMMARY OF CONCLUSIONS.

(1) We believe that the divergencies in the Rhodesian Ruins are primarily due to the use of platformed huts. These were grouped in villages, which in the West had external cattle-pens, and in the East had central cattle-pens. Thus giving rise respectively to the Western and the Eastern Complex.

(2) The divergencies in the ruins of the Western Complex were due to differing solutions of the problems arising from the continued occupation of a walled village site, after its levels had been raised by the successive erection of platformed huts on the same limited area.

  (i) The most usual solution was that of building a second wall or revetment, on the accumulated hut debris and within the ambit of the original wall. This process was frequently repeated a third time, and gave rise to the ruins with terraced walls such as Dhlo-Dhlo.

  (ii) Another solution was to build the secondary wall, and any successive walls or revetments, resting partly on the wall below and partly on the accumulated debris. So far as we know, this method was adopted on a large scale only at the Acropolis at Zimbabwe.

(3) Each of the methods served as the prototype for the erection of independent walls.

  (i) At Nanatali, and

(ii) At the Temple Ruin and the Great West Wall of the Acropolis at Zimbabwe.

(4) The Pit Circles of the Eastern Complex are the final development of the platformed hut and the central pen, combined with a tribal economy which centred around a pygmy breed of cattle.

(5) The practice of building platformed huts may have arisen from two distinct sources,—

(i) Many of the Bantu peoples of Southern Rhodesia previously dwelt in the Zambesi valley, where, in order to escape the flood waters of the river, huts and whole villages are built on artificial mounds called *liUba*.

(ii) There is a wide-spread practice of using hill-tops as village sites, not only because they afford refuge from enemies, but in order to escape the bitter cold of the lowlands in winter time.

In such positions the only practicable method of supporting the posts of the hut-walls on the rocky soil is to make a hut-mound or platform of heaped up earth upon which the build the hut.

(6) We regard the building of stone walls as being an autochthonous development with a geological rather than an ethnological significance.

(7) The Recent Prehistory of Southern Rhodesia can be divided into three periods, viz,—The Early Rhodesian Period, which we date as being prior to 1400 A.D., The Monomotapa Period from about 1400 to 1700 A.D., and the Mambo Period from 1700 to 1830 A.D.

It is possible to correlate these Periods with the following definite ethnological and/or cultural traits,—

Period.	Culture	Beads	Pottery.	Goldmining	Buildings
Early Rhodesian	Sotho	Uncertain	R_1	Alluvial	Uncertain
Monomotapo	Shono	1st. and 2nd Series	R_2	Alluvial and Reef	Perhaps Zimbabwe type & simple walling
Mambo	Roswi Venda	2nd Series	R_3	Reef and alluvial	Buildings with decorated &/or terraced walls

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Fig. 1. Diagram of the Development of Rhodesian Ruins.

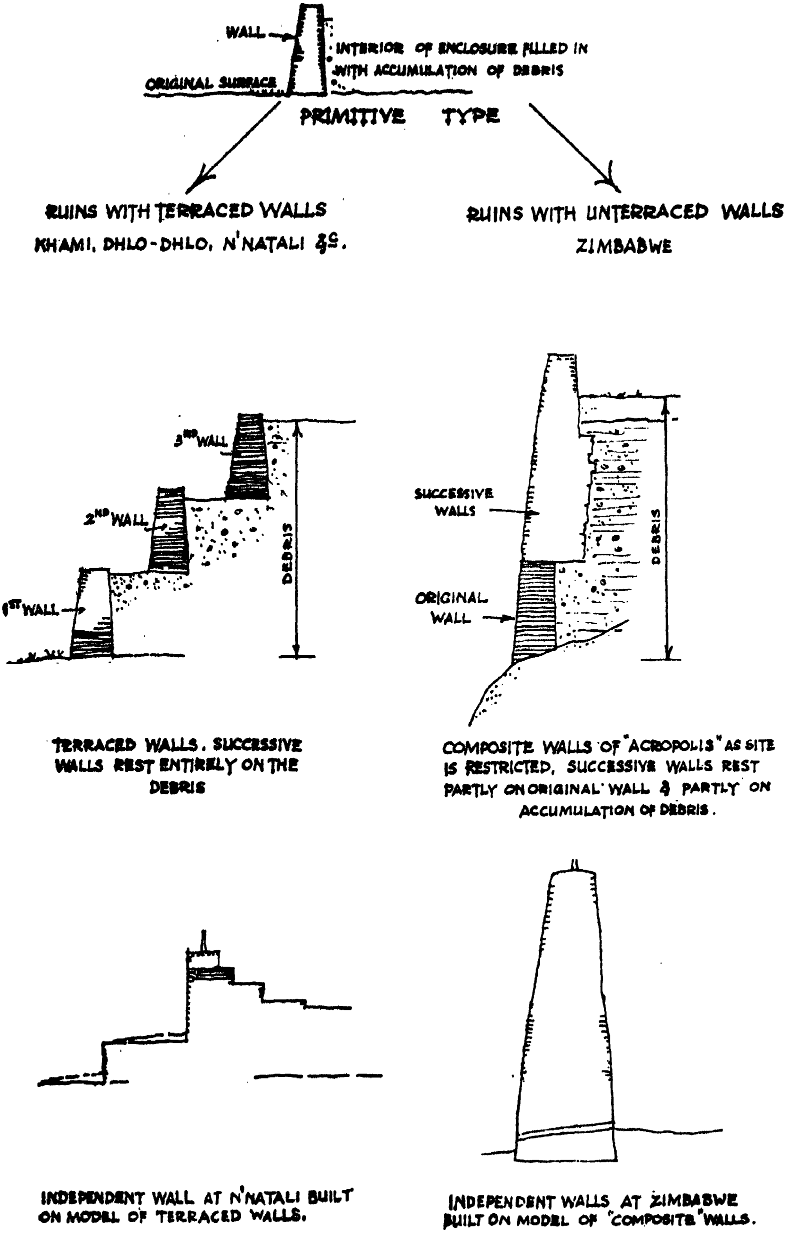
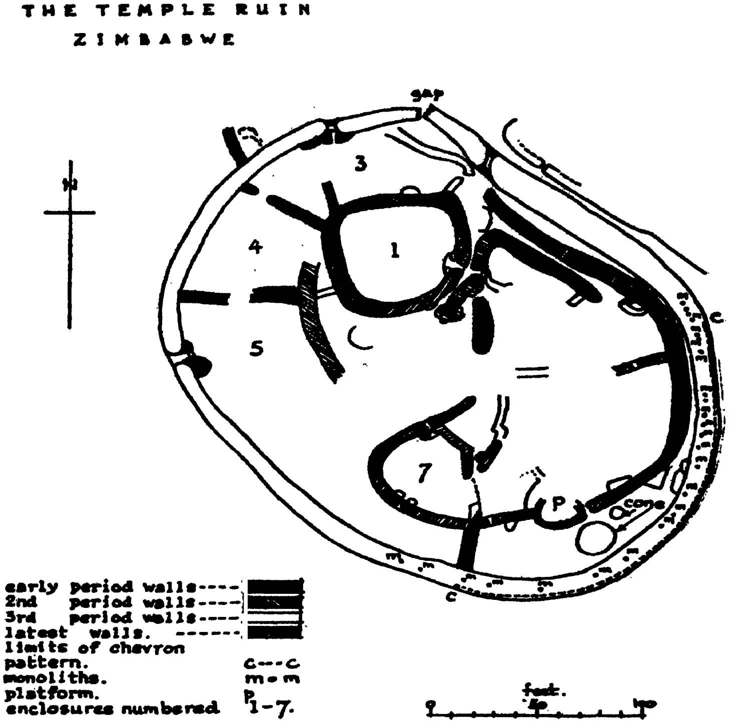

WALL
INTERIOR OF ENCLOSURE FILLED IN WITH ACCUMULATION OF DEBRIS
ORIGINAL SURFACE
PRIMITIVE TYPE
RUINS WITH TERRACED WALLS
KHAMI, DHLO-DHLO, N'NATALI &c.
RUINS WITH UNTERRACED WALLS
ZIMBABWE
3RD WALL
2ND WALL
1ST WALL
DEBRIS
SUCCESSIVE WALLS
ORIGINAL WALL
DEBRIS
TERRACED WALLS. SUCCESSIVE WALLS REST ENTIRELY ON THE DEBRIS
COMPOSITE WALLS OF "ACROPOLIS" AS SITE IS RESTRICTED, SUCCESSIVE WALLS REST PARTLY ON ORIGINAL WALL & PARTLY ON ACCUMULATION OF DEBRIS.
INDEPENDENT WALL AT N'NATALI BUILT ON MODEL OF TERRACED WALLS.
INDEPENDENT WALLS AT ZIMBABWE BUILT ON MODEL OF "COMPOSITE" WALLS.

Fig. 2.


THE TEMPLE RUIN
ZIMBABWE
gap
N
3
4
1
5
7
P
cone
C
C
early period walls
2nd period walls
3rd period walls
latest walls.
limits of chevron pattern. C--C
monoliths. m-m
platform. P
enclosures numbered 1-7.
feet.
0
50
100

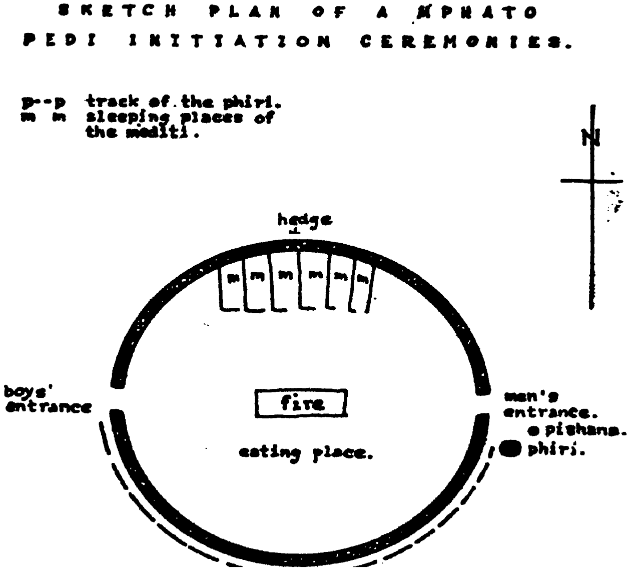
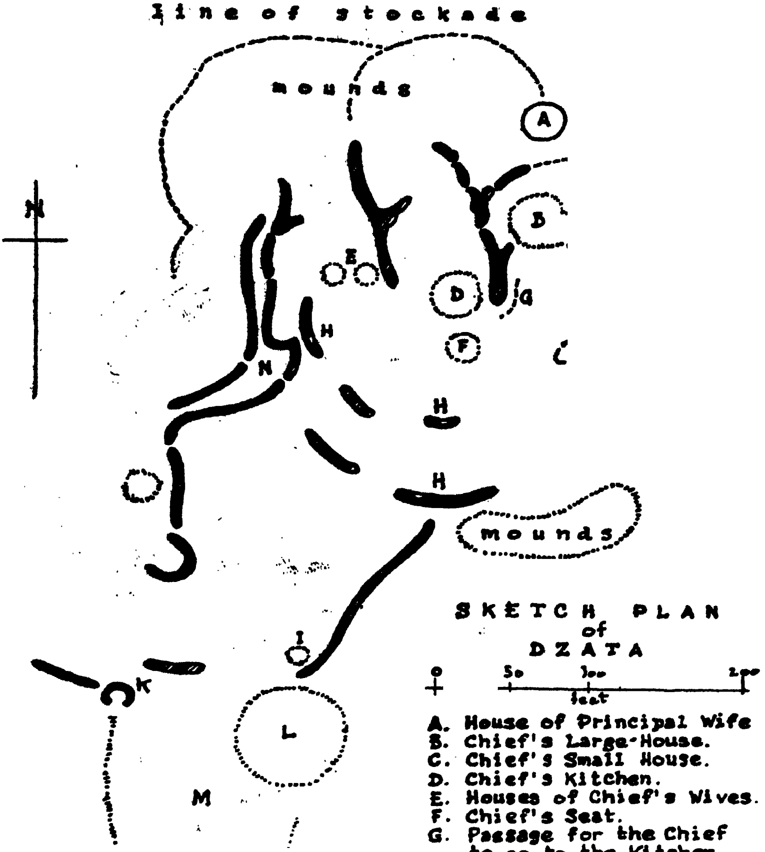

SKETCH PLAN OF A MPHATO
PEDI INITIATION CEREMONIES.
p--p track of the phiri.
m m sleeping places of the maditi.
N
hedge
m
m
m
m
m
m
boys' entrance
fire
eating place.
men's entrance.
o pishana.
phiri.

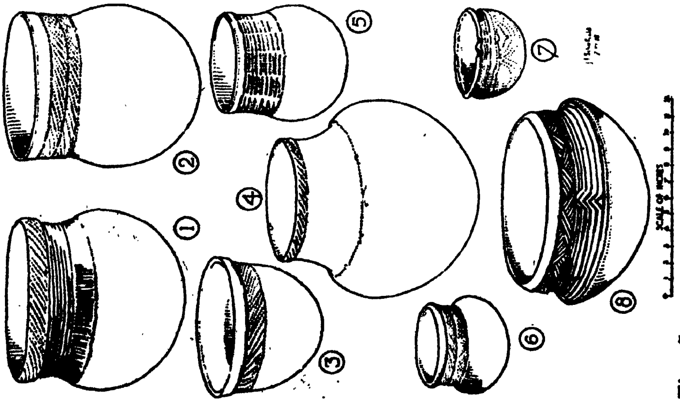
Fig. 3.

Fig. 4.



SKETCH PLAN of DZATA

A. House of Principal Wife
B. Chief's Large House.
C. Chief's Small House.
D. Chief's Kitchen.
E. Houses of Chief's Wives.
F. Chief's Seat.
G. Passage for the Chief to go to the Kitchen.
H. Walls with Chief's Seats.
I Chief's Seat when he watches the Cattle.
K. Court House.
L. Pen for Chief's Cattle.
M. Cattle Pen.
N. Principal Entrance.



Class R_1 Pottery from Gokomere.

Fig. 5.

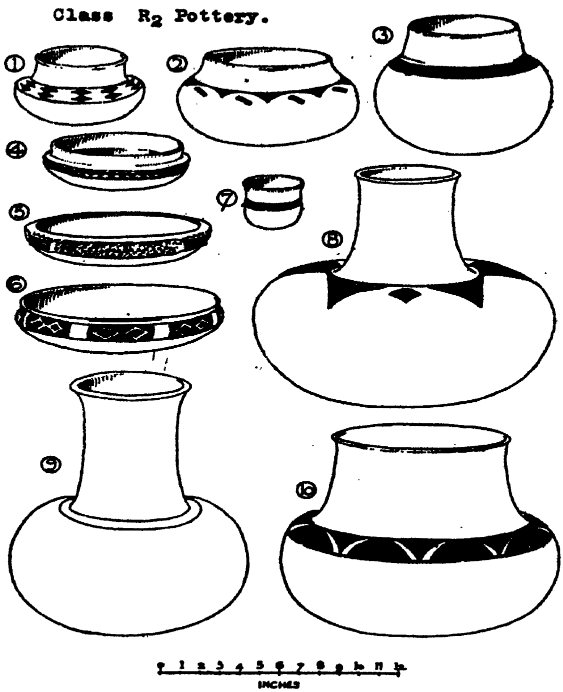


Fig. 6.

Nos. 1, 2, 4, 5, 6, 8 and 10 from Mapungubwe.
Nos. 3 and 7 from Zimbabwe. No. 9 from M'Telegwa.

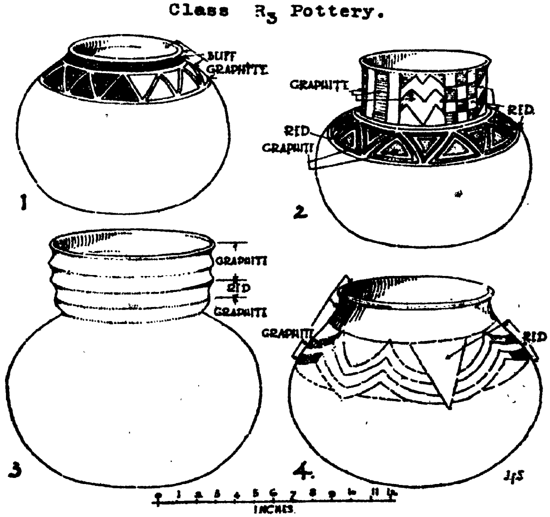


Fig. 7.

No. 1. Reconstructed from fragments from Dzata.
Nos. 2 and 3. Reconstructed from fragments from Khami.
No. 4. Reconstructed from fragments from Maryland.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XXXVIII, pp.* 112-132.
January, 1942.

SOUTH AFRICAN PUBLIC LIBRARIES

BY

S. B. ASHER.

Presidential Address to Section F, read July 1st, 1941.

In his Presidential Address on Education to this section, at our first joint meeting with the British Association 36 years ago, the late Sir Richard Jebb forecast the paramount importance to the future of South Africa of the educational requirements of the three great professions, the profession of Engineering in all its branches, the profession of Agriculture and the profession of Education itself upon which progress in every branch of knowledge so largely depends.

Since that time, the introduction of many industries into South Africa and their continuous mechanization; the progressive industrialization of the country which present conditions and public policy are now intensifying; the gradual obsolescence of traditional husbandry and the advent of scientific agriculture, together with the development of a psychological propaganda appealing to vestigial instincts, are not only leading to a reconsideration of the purpose and practice of both liberal and vocational education, but have made the provision of the means and aids for non-academical adult self-education a necessity for the attainment and preservation of essential economic, civic and ethical ends.

This Association has also in the past organized two very important symposia on the natural and on the human resources of South Africa respectively, but we still await a discussion on the most important resource of all, the key to all other resources, namely the knowledge which will provide our human resources with the power of utilizing the materials and forces in their environment for the satisfaction of supreme human needs.

I have therefore selected for discussion the present South African Public Libraries, so far as they concern the European population, because it is at this time important to consider whether they can serve as, or be converted into, efficient agencies for supplying the vocational knowledge required by industrialized masses to utilize their resources and fit them for imminent changes in their economic environment, and also for supplying the civic and ethical knowledge requisite for maintaining the stability of the nation and its human status, or whether they neither are nor can be adapted to implement these ends efficiently.

SUBSCRIPTION LIBRARIES

There are three classes of public libraries in the Union, viz.:—

(a) 241 Subscription Libraries.
(b) 11 Municipal Free Libraries.
(c) 2 National Libraries.

A few months ago the attention of the Minister of the Interior was drawn to the condition of the South African Libraries. It was stated in the Union Senate that an interdepartmental committee appointed in 1936 had reported that the present library position was highly unsatisfactory, and that in 1933 the librarian of the State Library in Pretoria had reported that of the 1,780,000 volumes contained in the public libraries, at least 1,000,000 were superfluous. No mention appears, however, to have been made of a more radical condemnation of these libraries by the latter authority two years later in a statement to an adult education conference in Durban, to the effect "That the average South African library might be described as a mere subsidized book club, run on sweated labour for the circulation of ephemeral fiction," and that "the real function of a library as our most important educational institution remained unrealised and unfulfilled."

A motion in the Senate that "The attention of the Government be drawn to the recommendations of the interdepartmental committee on the libraries of the Union with a view to the development of a national library policy and the organization of nation-wide library facilities," was welcomed by the Minister, who hoped that something might happen as a result of a fact-finding committee which the Government had appointed, and added the significant statement that "the Library was the poor man's University, a Library properly conducted and properly stocked."

This principle, having regard to the progressively vocational character of city universities, offers a standpoint from which the purpose of public libraries and their degree of achievement can be surveyed. In South Africa it would also form the justification for the control and support of the libraries—in an even greater measure than the Technical Schools—being vested in the Union Department of Education.

It would be useless to enter upon any consideration of South African Public Libraries without, in the first place, attempting to dissipate the confusion existing in the minds of the public and of some of the authorities mentioned, between those completely distinct institutions, the Municipal Public Free Libraries founded in Great Britain in 1850 *expressly* for national educational purposes, to which the term University was applied by Carlyle, and the circulating libraries for subscribers, introduced about a century earlier with very different objectives, the only distinction of the latter being that conferred upon them by Sheridan in the hackneyed saying that "A circulating library in a town is as an evergreen tree of diabolical knowledge."

The latter institutions are not mentioned in British Government reports, their work is not referred to in British official statistics, they are not regarded as in any way related to the national library system, nor do they in Britain demand or receive any financial assistance from the State.

The history of South African public libraries begins with the foundation of the first public library in the country by Lord Charles Somerset in 1818, long before the existence of parliamentary institutions in South Africa, before the recognition by the government of any responsibility for national education, and before even the foundation of any system of national primary schools. The objective of the library was declared by the founder to be:—

> "To lay the foundation of a system which shall place the means of *knowledge* within the reach of the youth of this remote corner of the globe."

Clearly a national educational institution was contemplated, and provision was accordingly made for the entire cost to be borne by the taxpayer. The proposed system was, however, never developed, and even the foundation was destroyed seven years later, on Somerset's retirement, when the funds provided for the library were devoted to other objects by an unappreciative official, the library being granted a small subsidy for a couple of years, and further state-aid discontinued.

The library was then abandoned to a committee which assumed full control, retained the name of the institution, and in order to obtain the necessary funds for its maintenance converted it into a subscribers' circulating library of the usual Eighteenth Century English type, an institution at that time common in Great Britain and popular with the leisured classes. During the 30 years which elapsed before a parliamentary government under Sir George Grey resumed its interest in the Cape Town library, a number of new libraries modelled on that subscription library came into existence in the larger towns of the Cape Colony, all of which adopted the same policy and practice, even assuming the title of public libraries.

The result of the reversion of Somerset's educational foundation to the eighteenth century model of circulating libraries was that when the echoes of the British agitation for free educational libraries and of the 1850 Act reached South Africa, a system of self-styled public libraries readily accessible to the leisured classes and providing them with a desired and partly gratuitous amenity, was already in existence; the impression prevailed and still prevails in some quarters, that the objectives of the British rate-supported libraries and of our local institutions were identical, so that natural conservatism and the self-confidence of vested interests made any change appear superfluous.

The lack of identical objectives will, however, appear from the following opinions on the local subscription libraries expressed by the Carnegie Commissioners who reported on them in 1929.

In an article by one of these Commissioners published in the (British) Library Association Record in March, 1929, the following is included:—

> "There are 211 institutions, styled 'Public Libraries,' in the towns and villages of the Union, over 200 of which lend books for home reading to subscribers only. With few exceptions, they owe their existence to the absence and unpayability of commercial circulating libraries in this country, and they are in fact proprietary subscription libraries. They differ from their commercial congeners, in not being conducted for financial gain, and in drawing, in theory, half of their expenditure from the Government and the Municipalities . . . 200 of the smaller libraries return an average circulation of 9,000 volumes per annum, of which only 8% is regarded as educational, whilst among eleven outstanding institutions such figures as 'nil,' 2.3%, 2.4% and 3.2% of the circulation are found as representing the issues of Educational Value."
>
> "The acceptance of a Government grant of funds entails upon these libraries the obligation of permitting non-subscribers to read the books and periodicals in the

> library premises. The prominence, however, given to the subscription qualification for membership, the general ignorance of a legal right to the use of the libraries, the scanty or non-existent accommodation provided for the public, and above all the general feeling that non-subscribers are intruders and recipients of a benefaction from a semi-private body, combine to deprive this right of any practical value in all but the largest libraries."

It might perhaps have been explained that there was no legal obligation to provide accommodation for non-subscribers.

The other Carnegie Commissioner to South Africa writes as follows in his report to the Carnegie Corporation (page 9)—

> "South Africa, you are told, is a land of sunshine, an outdoor country, a place where games and sports hold the attention and where reading *is a recreation and nothing more.* As a result of this condition . . . fiction alone is in demand, and of fiction only the latest, the best sellers, the thrillers, will go. Some committeemen on the book-selection group will tell you of their ambition to buy the more substantial and enduring works; but they point out the precarious position they occupy; love for the good, on the one hand, and on the other, subscribers who, if they do not get their stories, will complain, lose interest or even withhold the fee which makes the whole thing possible."

As regards the attitude of the provincial authorities, it is interesting to learn that although the regulations under which public funds were granted to libraries in the Cape Colony on the £ for £ principle dated from 1874, the public was only informed by a Cape Administrator's circular in 1921 that "It has been found that libraries have spent the Government grant almost wholly on fiction . . . and have neglected the building up of a collection of representative works of a more solid nature . . ."

A Regulation thereafter laid down that at least three-fourths of the Cape Provincial Government grant should be spent on books, and that as from 1st January, 1922, one-fourth of this book fund should be spent on works of an educative and non-ephemeral nature. This provision made an expenditure on non-fiction of 18¾ per cent. of the provincial government grant obligatory, and as that grant at that time amounted to 22 per cent. of the total income of the libraries, a sum equal to about *four per cent.* of that income was to be spent on works of an educative and non-ephemeral nature. Although the observance of this obligation was not verified, the presence of the regulation in the provincial code was apparently regarded by the authorities as sufficient to entitle the libraries to rank as Educational Agencies and to participate in the proceeds of public taxation.

SUBSCRIPTION LIBRARIES: WORK AND COST.

The essential statistical data required for a consideration of the subscription libraries are: (1) an analysis of the character of their work as shown by the proportions of different classes of books circulated, (2) the proportion of subscribers to the local population, and (3) the respective financial contributions to the cost of the work made by the subscribers and by the general public through National, Provincial and Local Governments. The supply of this information to the authorities and to the general public would seem to be the raison d'être of official library statistics and to be an indispensable preliminary to assigning public funds for the support of the libraries. I have summarised the figures available in the Official Year Book of the Union published by the Department of Census and Statistics and have drawn attention to their probable value and to necessary adjustments.

TABLE I. CHARACTER OF CIRCULATION.

Dates	Number of Libraries	Circulation		
		Fiction	Technical and Educational	Other
1913 to 1917	154 to 218	79·91%	——	20·09%
1918 to 1933 except 1930	211 to 245	78·22%	12·46%	9 32%
*1934	246	79·1%	9·8%	11·1%
1934	249	74.·%	14·7%	10·5%
1935 to 1940	253 to 254	No classified data published		

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* The two National Libraries and the Johannesburg Municipal Library are omitted from the figures in this line which are calculated from the figures in the Year Book.

The above table does not fully represent the recreational character of the subscription libraries, the heading "Fiction" applying only to English novels, fiction in other languages and juvenile stories being generally classed, during the periods shown, under another heading. Further, the inclusion of national and municipal libraries, with great reference collections, in the totals for the subscription libraries is misleading; in 1934 for example, the last year for which classified data were given, the inclusion of the figures for the two national libraries and the Johannesburg library increases the average percentage of alleged technical and educational issues of the 246 subscription libraries by fifty per cent.

In the absence of instructions from the Department of Census as to the books to be included under the heading " Technical and Educational," and in view of the staff of many subscription libraries consisting of part-time and voluntary workers, the figures under that heading can only be regarded as an approximation. Since 1935 the Census Department, at the instance of the Association which represents the subscription libraries, has ceased to require that books issued by the libraries should be classified in their returns according to their character, a distinction being made only between books issued to adults and to juveniles. The reason for this departure may possibly lie in the doubtful accuracy of the classified results previously obtained, but this neither justifies the suppression of the figures for fiction issues which everyone can recognise nor the lack of proper instructions for an approximate classification. The present practice results in preventing any estimate *at all* of the educational value of the current library circulation being available to the public.

The number of subscribers to libraries individually being only given officially in respect to a list of 11 or 12 important urban institutions, collective figures being given in addition for each province, it was necessary in order to obtain an approximate figure for the percentage of the population subscribing to local libraries, to take the number of members of subscription libraries with few or no free readers from the above-mentioned list for 1936, when it could be compared with the census results for the local population in that year.

The figures showed that urban populations numbering 354,656 provided 10,741 subscribers, an average of 3.03%.

The proportion of the Revenue of the subscription libraries contributed by the subscribers to the above group of libraries is not disclosed in the Official Year Book, the items given being the total of the Union and Provincial Government grants, and an omnibus figure designated "Other" including Local Government Grants, Subscriptions and sundry revenue. The undermentioned figures for the Local Government Grants and Subscriptions have been obtained from the Municipal Year Book.

REVENUE OF PROMINENT URBAN SUBSCRIPTION LIBRARIES.

OFFICIAL YEAR BOOK		MUNICIPAL YEAR BOOK	
Total Revenue	£29,514	(£29,514)	
Union & Provincial Government Grants	£4,385=14·85%	£4,396=14·9%	52·42%
Local Government Grants	——	£11,075=37·52%	
Subscriptions	——	£11,447=38·8%	
Other	£25,192=85·15%	(£2,596=8·78%)	

The omission of the Local Government Grants from the official total of Government grants has made it appear that *under 15 per cent. of the revenue of these subscription libraries was obtained from public funds, whereas, in the instances given, 52·42 per cent. of the revenue was supplied by the public for the benefit of 3·03 per cent. of the local population. The combination of Local Government grants with subscriptions and sundries, dates, however, from the earliest issues of the Official Year Book, and it is hoped that the recognition of the misunderstanding to which it gives rise may lead to a reconsideration of the practice. The other main purpose of the publication of official statistics of libraries would also be implemented if a significant and verified account of the character of the work of the subscription libraries were disclosed to the public.

It is regrettable that the authorities who are guided by the statistics given in the Official Year Book could not be permitted to realise that 50 per cent. of the cost of 240 sub-

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* Note: Official Year Book No. 17. *neglecting Local Government contributions,* shows the average Government grant over the 10 years 1925-34 to 215-249 libraries as barely 17.0 per cent. of their total receipts, whilst the Year Book for 1940 gives an average grant of 17.6% for the 5 years 1934-38 in respect to 249-254 libraries.

scription libraries was provided by the payers of taxes and rates for the supply of the mainly recreational requirements of three or four per cent. of the population, as the relevant funds might have been diverted to definitely educational ends.

During the last twelve years there has been a continuous effort to prevail upon the owners of subscription libraries to surrender their property to public authorities for the free use of the public and to induce these authorities to provide the necessary funds, but success has only been achieved in a few exceptional cases. On the Rand Goldfields some wealthy municipalities have followed the example of Johannesburg and provided all their citizens with free libraries of the same recreational type as the subscription libraries, but outside the Rand only three of the 246 libraries in the Union have become free to the public. The reasons for this failure are:—

(1) That nearly all subscription libraries are privately owned and controlled by social groups who do not desire any public interference with their control, with their choice of amenities, or with a membership qualified by the payment of a subscription. At present, subscription libraries are entirely autonomous, unless they accept a provincial grant, and in that case public control is strictly limited to two or three points defined by regulation and not often enforced.

(2) That most subscription libraries are not dependent upon the provincial grants for their existence. In Natal only two such grants are made, no grants at all are made by the Orange Free State, and most libraries in the Transvaal survived the period 1923 to 1926 during which they received no provincial grant.

(3) That public authorities are reluctant to become responsible for free libraries probably owing to the feeling that they would in general only be distinguishable from the subscription libraries by their greater membership; that their educational achievement is insignificant, and that they mainly provide a form of entertainment which has no greater claim upon the taxpayer than more popular diversions, and far less than any municipal utilities.

MUNICIPAL FREE LIBRARIES.

The establishment of rate-supported Municipal Free Libraries was first authorised in Great Britain in 1850, as a result of many years' agitation by Ewart & Brotherton for the provision of free educational libraries for the nation.

This agitation culminated in the appointment in 1849 by the British Government of a Select Committee to report on the subject and ultimately in the adoption by Parliament of the 1850 Library Act. The report of the Select Committee clearly indicated the objective of the libraries recommended, viz.:—

> " A free public library ought, above all things, to teach the teachers, to supply with the best instruments of education those who educate the people, whether in the pulpit, the schools or the press."

The title of "The People's University" has been applied to public free libraries of this character and was derived from Carlyle's dictum that " the true University of these days is a collection of books," an opinion which he amplified by saying that " After all manner of professors have done their best for us, the place we are to get knowledge is in books." This conception of a public free library, as a super-university, providing the fullest information on *all* subjects, offering communion not merely with instructors and colleagues but with the greatest minds, regarding other educational institutions as propaedeutic, providing the foundations, methods and tools for a life-long study of books, can obviously only be fully realised in great national institutions, but it may form the ideal and the goal of every part of a national library system.

The essential character of the Municipal Public Free Library as an educational institution has been constantly upheld and emphasised by the British authorities in spite of Municipal panderings to a sectional craving for the substitution of recreation for education.

In 1917 at the 40th annual meeting of the British Library Association, the following resolution was adopted:—

> " The aim of the library as an educational institution is best expressed in the formula ' self-development in an atmosphere of freedom,' as contrasted with the aim of the school which is ' training in an atmosphere of discipline.' In the school the teacher is dominant, but the pupil strikes out his own line in the library which supplies the written material upon which the powers awakened and trained in the school can be exercised."

In 1919 the British Government commissioned a committee known as the " Master of Balliol's " committee, to report on adult education. In their third interim report, the committee say—

> "The library is part of the educational fabric just as the Art Room or the School Clinic."
>
> "*The unsystematic and recreative reading which the libraries have stimulated do not, however, it seems to us, provide any argument for maintaining the public libraries as an independent public service.*"
>
> "It is with no desire to subordinate the libraries or belittle their importance that we recommend the union of educational and library administration. We think that the local educational authority should be the authority responsible for the administration of public libraries and public museums, in order to ensure the closest relationship between the activities of schools, libraries and museums. *In England and Wales the local authorities for Higher Education should be the authorities for libraries and museums.*"

In their final report, the Committee state:—

> "We made a survey of existing libraries and we gave reasons for supporting the proposal to transfer the administration of public libraries to the local educational authority and we recommend the union of educational and library administration."

The latest British Committee on libraries state in their report (1927 and 1935) that:—

> "The public free library is recognised . . . as the essential foundation for the progress in education and culture without which no people can hold its own in the struggle for existence."

The system of Municipal Public Free Libraries which also exists in Canada, was the object of investigation by a Carnegie Commission in 1930 to 1933, and in their report the Commissioners state:—

> "The essential qualifications for a good Library Act should provide for—
>
> (1) *A definite statement of the purpose of a public library, basing its claim for public recognition and financial support on the same grounds of service as other educational institutions such as Schools and Colleges.*

(2) A central supervising and energising agency.
(3) Representative and responsible management.
(4) A sure and adequate income."

"Throughout eight of the provinces" (of Canada) "public libraries have been *abandoned* by the governments to the municipalities. For city and town libraries no supervision is exercised, no standards of service set . . . This condition can easily be remedied. It can be done by the legislative assertion of the principle that the public library is part of the education system . . ."

"If it is recognised that no one can be educated without books, it inevitably follows that a government should put libraries in the same class with schools, making both compulsory. This contention rests on the basis that modern thought realises that education of all the people is necessary to the preservation and the permanence of a democratic form of government."

In the United States of America where so many state-supported free libraries owe their existence to Carnegie benefactions—themselves inspired by educational zeal,—there are, in addition to some outstanding institutions of national importance and value, a great majority of libraries where the authorities, municipal or provincial, share the sectional choice of free entertainment in preference to essential educational service. To these the following account still applies (1).

"In America, the ideal seems to be to obtain the most popular books, those that will circulate best, and many an up-to-date committee will buy no book, keep no book, that is not a good circulator. More often than not the American library is a club for the reading of new books—frequently only of new novels."

A questionable artifice which may not be unknown outside America, but which appeals with equal success to the public purse and to the vulgar admiration for big figures, is also pilloried by the same author (2) who writes:—

"In one State of America, where the amount of Government grant is based on the issue, the result has been to excite a feverish desire to increase the issue alike by Library Boards and staffs, and while the Library Boards would only buy such books as were good 'circulators,' without consideration whether such books were of real value to the community, the library staff insisted on every unfortunate user of the library taking out, each time he or she visited it, two books, one of which might not be fiction—despite reluctance or protest—and all because of the statistics."

That these ideals still persist and are recognised as a *corruptio optimi,* appears from the following statement on American libraries made by the chief librarian of the great Carnegie Foundation at Pittsburg, delivered at the Annual Conference of the American Library Association in 1937, viz.:—

" Our first aim is to make certain that our libraries do fall within the definition of an Educational Agency. Libraries which . . . buy several hundred new fiction titles each year and maintain expensive services to carry on a large circulation of novels, *are backsliders,* and should be represented on the mourning bench."

In his Presidential Address to the American Library Association in 1938, Mr. Harrison Craver stated: " In its value as an instrument of Education resides the chief argument for a Public Library. Valuable as it may be as a means of public recreation, no one of us would be content to argue for its continuance on that ground alone."

" If Libraries are to live, their final appeal will have to be based upon some more substantial contribution to society than the providing of recreation. Unfortunately in the minds of many people to-day that is their chief function: Equally unfortunate this impression is uncomfortably close to the truth in some cases. *The coming generation of librarians must face the task of converting libraries into something different—and more worth while.*"

A Statement of Policy adopted by the Council of the American Library Association on the 26th December, 1940, (8) reads as follows:—

" The American Library Association declares that Libraries must help the unskilled, unemployed man preparing himself to hold a job in an essential industry; the skilled worker preparing himself for greater responsibility; the engineer re-educating himself for defense activities; the designers of airplanes, motors, tanks, guns and ships; the research workers in science and industry; the farm worker who must adjust himself to new economic conditions . . ." " The Library cannot work alone, but must co-operate with all other agencies concerned with research, education, training and the diffusion of ideas." " The diffusion of knowledge and understanding was never more important to the welfare of mankind."

The statements quoted will leave little doubt that the primary and fundamental functions and objectives of the Municipal Public Free Libraries, with which our subscription libraries are so often confused, are educational, and that their implied deterioration and failure to implement the functions of educational institutions is due to the control being entrusted to municipal bodies which are incompetent to act as independent educational authorities.

SOUTH AFRICAN MUNICIPAL FREE LIBRARIES.

Since the municipalization of the Johannesburg Public Library in 1924, eight subscription libraries on the Rand and three such libraries in other parts of the Union have become Municipal and Free. It has been a great disappointment to many advocates of these libraries that the character of the literature circulated has not, however, been affected materially by the change of control and remains that of the preceding subscription library. This result supports the views of the Master of Balliol's Committee and of the Carnegie Canadian Commission, as regards the educational inadequacy of municipal control and the necessity of library control being exercised by a National Department of Education.

The attitude of some enlightened municipal library committees may be illustrated by the following quotation from an annual report to such a committee, by a librarian whose issue of fiction (excluding Afrikaans, foreign and juvenile stories) had unfortunately fallen in a particular year from 77 per cent. to 75 per cent. of the total issue.

> "It is distressing"—writes the librarian—"to have to report a large decrease in the number of books of fiction issued. This is undoubtedly* due to the competition of the numerous 'tickey' libraries which have sprung up all over town and which cater for the light reading of so many of our citizens. *The only way to regain lost ground* will be by the establishment of a library service in the suburbs."

Needless to say, the suburban service called for was before long provided.

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*Note: Gresham's Law, as applied to amusement ousting education, is illustrated in an account of a Municipal Travelling Library in the Johannesburg Star of 13/1/42, viz:—"The demand is almost exclusively for popular fiction.........." "As at the Public Library, three tickets, *two for fiction*, and one for non-fiction, are allowed." "Very few people make use of their non-fiction ticket, and scores ask.........to take a novel out on it."

Under present conditions, it has become evident that with few exceptions, the Municipal Free Libraries formed by the conversion of subscription libraries, so far from serving to supply the educational and informational needs of the local population, exceed both the subscription and the tickey library in the provision of recreational attractions to a wider circle of readers at the public expense, thereby enlisting a larger measure of popular support for their continuance. It must therefore be held that the existence of most of the converted libraries is at present among the greatest hindrances to the establishment of the most important agency for adult education which a nation can have. Inasmuch, however, as the local government finance upon which the free library entirely depends can be subjected to national control, their policy and practice could be radically revised and the necessary changes safeguarded by a rigorous educational control.

SCHOOL LIBRARIES.

School Libraries are everywhere recognised as an essential part of an educational system, and their aims, uses, equipment and operation are fully dealt with in the relevant literature. In this country there are over 4,000 schools, most of which own collections of books often regarded as libraries. Owing, however, to traditional economies and to a local lag in educational development, a mere fraction of the four thousand possess libraries equipped with the necessary material and operated so as to implement their real aims. The provision of books is too often dependent upon parental contributions, and the library service generally devolves upon a fully occupied staff, with the result that a haphazard delivery of books from a casual collection is made at varied intervals to unguided children.

The essential condition for the formation of a School Library is that the selection of books should be made by the best available talent acting upon the supreme principle that all books should be the best and latest on their subject. The second best should on no account be admitted, and no matter how popular a book may be, it should be banned if it contains inaccuracies. *The child must be given nothing to unlearn.* What matters is not how many but how good are the books available. The recognised aims of a School Library are:—

(1) To provide the material affording the best assistance for the routine work of the school, both to pupils and teachers. The latter should have access to the literature

which would enable them to arouse and stimulate the interest of the pupils in the subjects taught.

(2) To afford the pupils opportunities for the formation and growth of individual interests and pursuits outside the ordinary routine work. The presence in the library of the best popular works on all branches of Science, Art and Industry, History, Biography and Literature is therefore essential.

(3) To supply the pupils with sources of information on current topics of the day and to assist them in the acquisition of general knowledge.

(4) To encourage voluntary work by pupils in finding things out for themselves.

(5) To foster a love of reading.

(6) To provide for the juniors, school stories and stories of adventure, exploration and heroism, which, when selected with sufficient care, offer many admirable models of uprightness, loyalty, generosity, enterprise and courage, and present standards of conduct, values and ideals of the good citizen to the impressionable mind of the young. Few, if any, primary schools and only a small proportion of the high schools in the Union either possess or are in a position to provide the three essentials of a school library, namely a meticulous and adequate selection of books, together with permanent accommodation and competent guidance for readers; and the primary aims of the school library cannot therefore generally be considered. The letterpress sometimes offered to schools by circulating libraries and other non-educational bodies not being purposive, requires the strictest scrutiny before admission into a school library as it may contain much second-rate, time-consuming and even formatively harmful material.

The only promising method of ensuring general compliance with the essential condition of the formation of a school library and of advancing its aims would be for the educational authorities to form a national basic collection of the best books on the subjects taught in the schools and on the subjects previously mentioned, to provide a set of this collection for every school, and to supplement it annually by new additions and replacements. For the efficient discharge of the national responsibility it would further be necessary to provide accommodation in school premises for children not engaged in class work who may wish to consult the books, and to make competent guidance available whenever required

It cannot be too strongly emphasised that the basic school library collection, upon which the greater part of the general knowledge of school children, and in many cases the whole of their civic and ethical principles, will depend, should differ widely from the children's books found in the miscellaneous stock of circulating libraries and in the representative collections of the greater municipal libraries, inasmuch as its contents must be individually selective and purposive, free from error and the best of their kind.

Rural Library Services.

An Urban Area is defined as " an area included within any city, borough, municipality, village management, health committee, township or other local board constituted under any law and possessing some form of Urban Local Authority."

So far as the European population is concerned a " Rural Library Service " is therefore a Farm Service, including libraries in farm schools, where no form of Urban Local Authority exists, since all dorps, villages, hamlets, etc., are urban. The statistics given in recent Official Year Books of a Rural Free Library Service financed by the Transvaal Provincial Government, elsewhere stated to consist of about 200 stations in dorp and village schools, possibly including a few farm schools, and in Agricultural Union branches, suggest but do not represent the existence of a farm service. The statistical record of library borrowers in the Union under the ambiguous terms " Town " and " Country " has the same effect.

Actually the so-called " Rural " service consists at present of the delivery of boxes of books several times a year to 176 dorp schools and to 24 Agricultural Union centres mainly situated in dorps. In addition to the usual literature, a proportion of children's books is included in the school consignments. The service to the resident urban population, which is conducted gratuitously by the schoolmasters, is limited by the school requirements and is suspended on school holidays and week-ends. Farmers in the immediate neighbourhood of the stations are able to borrow books from the schools, but as their visits are generally made on Saturdays when the schools are closed, this facility is greatly restricted. As regards the supply of children's books, the disadvantages of using such material from circulating and general libraries for the formation of school libraries have already been mentioned.

In the Cape Province, it appears that the Society for Book Distribution has established 43 "Rural Library Centres" in conjunction with schools, Die Helpmakaar A.C.V.V., the Agricultural Union (Woman's Section), Excelsior and various Leeskringe. Most if not all these centres appear to be situated in urban areas. No statistics are available of the character of the issues to adults from the Transvaal and Cape school stations, but there is no reason to believe that it differs to any extent from that of other small urban circulating libraries.

The provision of government subsidies to private bodies for the free distribution of books to the public, in lieu of such work being conducted by a National Department of Education, not only disregards the fact that the interest of the State in libraries and library substitutes should be entirely confined to their educational work, which under present controls forms a negligible fraction of their activity, but also that such financial support offers facilities for the dissemination of detrimental and subversive propaganda at the public expense. The full and valuable educational and agricultural library service already provided by the Union Government to farms and country schools freely or at a trifling cost from the libraries of the Union Agricultural Department and of the National Bureau of Education and Social Research could serve the entire educational needs of the Transvaal farm population by comparatively small additions to those libraries, whilst industrial literature could be supplied from a specific regional industrial collection in Pretoria. Village schools with their many disabilities are unfitted for a farm service and the supply of wanted books from State collections were best entrusted to the Police Depots. There seems no reason for the maintenance of an alleged "Rural" service, supplying the residents of a number of small dorps and a small percentage of neighbouring farmers with a gratuitous circulating library service at the taxpayer's expense. The educational facilities afforded by the Union libraries are perhaps insufficiently known and should be brought to the notice of every farmer and every farm school.

The Future.

The object of this brief survey of South African libraries has been to draw attention to the national duty of supplying adult industrialized masses with the means of acquiring the knowledge requisite for the planned economic basis of the

South African nation, and for its civic and ethical superstructure. In the schools vocational education and training still forms an unimportant part of the courses, and in deference to a petty and outworn economy, the young have been left without the reinforcement and complement to their education obtainable from properly stocked, staffed and organised school libraries; and in many cases a time-consuming and educationally ineffective if not harmful substitute has been allowed to develop.

The vast majority of adults and adolescents, to whom. outside their occupations, books are the main sources of knowledge, have a nominal right to consult some hundreds of circulating libraries owned, stocked and conducted by subscribers to provide, co-operatively and in part at the public expense, the latest of fiction and other library anodynes against boredom and depression. It may be confidently asserted that there are not a dozen public libraries in the Union with a collection of books on applied science and art, industries and manufactures, which it would be worth while for our future industrialized masses to consult, and that there is not a single public library in the country with a full range of up-to-date books on every branch of these subjects.

On the social, civic and ethical subjects, a number of miscellaneous volumes representing a variety of theories, and of different degrees of authority and value, would be found in most libraries, but there are few if any public libraries which possess systematic collections of the most important works on these subjects.

What of the future? If it is recognised that South Africa is "on the threshold of vast industrial expansion involving the transformation of a large percentage of the population into industrial operatives," adequate institutional and private facilities should be provided for that transformation to be successful. The minimum facilities can at present be visualized as a large measure of vocational training in the schools, the formation of normal school libraries, and free and ready access and *expert guidance* to up-to-date collections of the fullest and best industrial and educational literature.

In order to achieve success in a great national enterprise, unity of action is indispensable, and the educational provision for our imminent industrial revolution should therefore become the duty of a single educational authority, appointed *ad hoc* and implementing uniformly a clearly defined national policy, a prerequisite to which is acknowledged to be the supply of the fullest information on all industries.

As over ten million pounds are already spent annually on European education, it would be necessary, in order to render a large extension economically possible, to confine the new policy in the first instance to the supply of hitherto unobtainable essential literature to the essential industrial centres, where the books would be immediately available to a majority of the working population, and whence they could be sent to enquirers in the district.

The establishment of a number of fully stocked central regional libraries in the Union, in lieu of one central institution, is indispensable for industrial purposes, in spite of the additional cost, as time is an important element in industry and it often happens that the information needed by the engineer, industrial worker or manufacturer loses its value if it is not immediately available. Whilst the investigator or long-range research worker may benefit from the widespread enquiries of a central library for students, industrial questions may require an immediate reply which can only be given by a technically qualified librarian in a fully equipped special library.

The majority of the South African manufacturing industries are established in five municipal areas or in their vicinity, namely Cape Town, Pretoria, Johannesburg, Durban and Port Elizabeth, where communications, power and water supplies are now well developed and labour is readily obtainable. As all new industries will require the same facilities, it is reasonable to assume that these centres will remain the chief seats of industry in the Union. The population of these five centres was found in the 1936 census to be 654,500 or just over 50 per cent. of the urban population of the Union, and an increase of this percentage will probably be shown in this year's census. In view of the concentration of industries in these areas and in their vicinity, in all probability 75 to 80 per cent. or more of the total demand for industrial knowledge could be adequately dealt with by properly equipped libraries in these centres.

The existing libraries in Cape Town and Pretoria are State institutions and could without much difficulty be converted into the required regional libraries, some of the social, civic and ethical material and the technical staff would need to be supplied; the Johannesburg and Durban libraries being entirely dependent on Local Government funds could also be brought under the control of the Union or Provincial Department of Education, the Johannesburg library which contains a large collection of technical literature—the Seymour library—would require a considerable supplement, and the Durban library would require very large accessions of technical and industrial material; finally the Port Elizabeth library being dependent on the subscribers only, could not be utilized primarily for industrial purposes, and the establishment of a separate regional library would be necessary.

The co-operation or utilization of institutions founded and needed now and in the future, for sectional purposes, even if obtainable, would introduce a diversity of opinion, effort and tendencies conflicting with national economic objectives, impairing unity of action and efficiency, and in some cases leading, as shown in the Cape Administrator's circular, to funds provided for national education being diverted to other services.

For the efficient operation of an industrial library service, not only must all the subjects be fully covered in detail, but the staff must be conversant with many subjects and technically competent to guide enquirers. They should not be merely custodians of books but custodians of information, and should have the ability and the zeal necessary for extending the use of the service to every part of the country. Both willing service, competent guidance and expeditious transport arrangements are essential for economic success.

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A STATISTICAL STUDY OF MASS, DENSITY, AND RADIUS IN SOME ECLIPSING BINARIES

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Read 30th June, 1941.

1. Elements of a reliable nature have been determined for a number of eclipsing binaries. From these elements we have selected for statistical discussion the mass, density, radius, bolometric magnitude, and temperature for 46 stars, of which 29 are the brighter components, 17 the fainter components of eclipsing binaries. These stars were chosen for the accuracy of the elements.

The material used was taken largely from Gaposchkin's monograph (1932), with more recent material added from various sources, such as Walter (1938). Data for the 29 brighter components are given in Table I, and for the 17 fainter components in Table II. In these two tables, successive columns give:—

(i) The name of the star;
(ii) the quantity $x = -\log D$, where D is the mean density;
(iii) the quantity $y = \log a$, where a is the radius of the star, that of the sun being taken as unity;
(iv) the quantity $z = \log M$, where M is the mass of the star in terms of that of the sun as unity;
(v) the quantity $a = M_b$ where M_b is the bolometric absolute magnitude;
(vi) the quantity $b = \log T$, where T is the effective temperature of the star, deduced from its spectral type by the relation given by Brill (1930).

The material in these Tables represents the best information available at the time of the present investigation, and has not previously been subjected to statistical analysis.

TABLE I.
BRIGHT COMPONENTS.

Name	*x*	*y*	*z*	*a*	*b*
σ Aql ...	0·824	0·591	0·792	—3·07	4·260
AR Aur ...	·38	·27	·428	0·4	4·061
TT Aur ...	·89	·58	·845	—3·1	4·255
WW Aur ...	·733	·358	·342	0·97	3·991
β Aur ...	·959	·447	·380	—0·61	4·134
i Boo ...	—·342	—·194	—·194	5·68	3·775
RS CVn...	·35	·20	·27	2·76	3·870
RZ Cas ...	·495	·146	·114	1·36	4·134
TV Cas ...	·353	·212	·286	0·06	4·145
U CrB ...	·292	·286	·710	—1·53	4·260
Y Cyg ...	·80	·68	1·25	—3·67	4·322
Z Her ...	·553	·255	·204	2·27	3·895
RX Her ...	·55	·29	·34	—0·16	4·134
TX Her ...	·284	·199	·314	0·65	4·076
u Her ...	1·00	·66	·88	—3·42	4·260
AR Lac ...	·66	·27	·15	3·8	3·716
CM Lac ...	·06	·12	·30	1·7	4·000
β Lyr ...	3·40	1·634	1·27	—8·12	4·260
U Oph...	·74	·51	·73	—2·56	4·245
AG Per ...	1·00	0·57	·71	—3·1	4·255
β Per ...	1·131	·608	·663	—1·58	4·156
V Pup ...	1·301	·88	1·326	—4·89	4·300
U Sge ...	2·05	·62	·83	—1·51	4·145
X Tri ...	·40	·29	·46	0·57	4·045
W UMa	—·28	—·11	—·15	5·0	3·820
ζ UMa A	·28	·23	·41	1·2	4·000
Z Vul ...	·79	·49	·68	—2·58	4·260
RS Vul ...	1·22	·63	·66	—2·28	4·156
Boss 46 ...	2·57	1·38	1·56	—7·8	4·36

TABLE II.
FAINT COMPONENTS.

Name	x	*y*	z	*a*	*b*
WW Aur ...	0·63	0·30	0·28	1·28	3·97
β Aur ...	·98	·45	·37	—0·61	4·13
i Boo ...	— ·34	— ·19	— ·19	5·68	3·78
RS CVn...	1·92	·73	·23	1·65	3·65
Y Cyg ...	·80	·68	1·24	—2·88	4·32
Z Her ...	1·40	·52	·15	2·32	3·90
RX Her ...	·47	·24	·28	0·07	4·05
TX Her ...	·35	·20	·25	1·16	4·08
u Her ...	1·48	·69	·46	—2·36	4·26
β Lyr ...	2·60	1·26	·85	—3·20	4·14
U Oph...	·80	·51	·67	—2·37	4·23
V Pup ...	1·30	·83	1·21	—4·52	4·26
U Sge ...	1·89	·73	·30	1·33	3·74
W UMa	— ·15	— ·11	— ·30	5·18	3·82
Z Vul ...	1·85	·73	·34	0·23	4·26
RS Vul ...	2·10	·75	·16	—0·31	4·16
Boss 46 ...	2·04	1·19	1·53	—6·52	4·32

2. *Statistical Analysis.* The material has been analysed in three groups: (i) brighter components, (ii) fainter components, (iii) all stars. In Table III, Table IV, Table V we give for these three groups in succession the Mean value and the Standard Deviation from the mean for each of the variables x, y, z, a, b.

TABLE III.

MEANS AND STANDARD DEVIATIONS—BRIGHT COMPONENTS.

Variable.	Mean.	Standard Deviation.	
x ...	0·808	0·764	
y ...	0·452	0·373	
z ...	0·571	0·415	(N =29)
a ...	—0·813	3·238	
b ...	4·113	0·171	

TABLE IV.

MEANS AND STANDARD DEVIATIONS—FAINT COMPONENTS.

Variable.	Mean.	Standard Deviation.	
x ...	1·183	0·811	
y ...	0·559	0·375	
z ...	0·461	0·480	(N = 17)
a ...	—0·228	3·109	
b ...	4·032	0·221	

TABLE V.

MEANS AND STANDARD DEVIATIONS—ALL STARS.

Variable.	Mean.	Standard Deviation.	
x ...	0·946	0·802	
y ...	0·492	0·377	
z ...	0·530	0·444	(N = 46)
a ...	—0·597	3·20	
b ...	4·096	0·169	

In Tables VI, VII, VIII we give the coefficient of correlation between each pair of these variables for each of the three groups of stars, along with their probable errors.

TABLE VI.
CORRELATION COEFFICIENTS AND PROBABLE ERRORS—BRIGHT COMPONENTS.

Variables.	y	z	a	b
x ...	0·975 ± ·01	0·780 ·05	—0·817 ·04	0·559 ·09
y ...	....	·880 ± ·03	— ·927 ·02	·700 ·06
z ...	....	....	— ·953 ± ·01	·845 ·04
a ...	....	....	....	·896 ± ·03

TABLE VII.
CORRELATION COEFFICIENTS AND PROBABLE ERRORS—FAINT COMPONENTS.

Variables.	y	z	a	b
x ...	0·937 ± ·02	0·439 ·13	—0·559 ·11	0·16 ·16
y ...	....	·750 ± ·07	— ·816 ·05	·473 ·12
z ...	....	....	— ·934 ± ·02	·325 ·14
a ...	....	....	....	— ·955 ± ·01

TABLE VIII.
CORRELATION COEFFICIENTS AND PROBABLE ERRORS—ALL STARS.

Variables.	y	z	a	b
x ...	0·958 ± ·01	0·590 ·07	—0·678 ·05	0·426 ·08
y ...	....	·795 ± ·04	— ·862 ·03	·643 ·06
z ...	....	....	— ·942 ± ·01	·862 ·03
a ...	....	....	....	— ·943 ± ·01

In each of these tables, the coefficients of correlation are arranged in a square array, so that the correlation between the variable in a given column and that in a given row is found in the given column and row. Thus for example in Table VI, the correlation between x and y is $0{\cdot}975 \pm 0{\cdot}01$.

In all three Tables, we find strongly marked correlations between the following variables:

x, y (density, radius)
y, z (radius, mass).
y, a (radius, bolometric magnitude).
z, a (mass, bolometric magnitude).
z, b (mass, temperature).
a, b (bolometric magnitude, temperature).

3. *Russell-Hertzsprung Diagram.* The correlation between bolometric magnitude and temperature, found for all stars to be $r_{ab} = -0{\cdot}943 \pm {\cdot}01$, is the expression of the closeness with which the individual stars fit a straight line in the Russell-Hertzsprung diagram.

The equation to this line is found by the usual methods to be $M_b = -20 \log T$ . . . (i) where for the sun $M_b = 0$, $T = 1$.

This is therefore the equation of the main series for the components of eclipsing binaries. This result agrees reasonably well with the equation derived some years ago for the main series of all stars (Bleksley, 1935), namely

$$M_b = -15{\cdot}2 \log T + C$$

The difference in the coefficients of log T in the two equations is almost entirely due to the difference in the temperature scales used in the investigation quoted and in the present one. The temperature scale used in the earlier work was my own, which is wider in range than that due to Brill.

The agreement justifies us in assuming that the components of these eclipsing binaries are normal stars, lying on or near the line of the main series. Any results found for these stars may therefore be carried over with a reasonable degree of assurance to the members of the main stellar sequence in general.

4. *Mass-Luminosity relation.* Of the remaining correlations indicated in the above Tables, the main interest lies in those of a predictive value.

Thus the mass (z) is found to be correlated very strongly with the bolometric absolute magnitude (a), and less strongly with the temperature (b), since from Table VIII we have

$$r_{za} = -0{\cdot}942 \pm {\cdot}01$$
$$r_{zb} = 0{\cdot}862 \pm {\cdot}03$$

A regression equation based on the first of these correlations enables us to calculate the mass from the bolometric absolute magnitude with a reliability of approximately 90 per cent. If the second correlation be taken into account as well, the coefficient of multiple correlation $R_z(ab)$ is found to be 0·975. This can be interpreted roughly as showing that the mass can be calculated from a knowledge of the bolometric absolute magnitude and the temperature with a reliability of about 95 per cent. The increased reliability gained by introducing the temperature does not at this stage appear to justify the more complicated calculations required in the second case.

The linear regression equation for z on a is found to be

$$z = -0{\cdot}13\ a\ + 0{\cdot}62$$

$$\text{i.e. } \log M = -0{\cdot}13\ M_b + 0{\cdot}62 \pm 0{\cdot}09 \ \ldots \ \text{(ii)}$$
$$\pm\ {\cdot}01$$

From this regression equation we can calculate the mass from the bolometric absolute magnitude with a probable error of 9 per cent.

5. *Density-Radius relation.* The correlation between mean density and radius is also very high. From Table VIII we have

$$r_{xy} = 0{\cdot}958 \pm {\cdot}01$$

This gives a regression line whose equation is

$$\log D = -2{\cdot}0 \log a \pm 0{\cdot}10 \ \ldots \ \text{(iii)}$$

If the radius is calculable, e.g. from the absolute magnitude and colour index, the mean density of the star can be computed from this equation with a probable error of 10 per cent.

6. *Radius and Absolute Bolometric Magnitude.* The remaining relation of predictive value is that between radius and absolute bolometric magnitude, for which from Table VIII we find the coefficient of correlation,

$$r_{ua} = -0{\cdot}86 \pm {\cdot}03$$

This gives the regression equation

$$\log a = -0{\cdot}11\ M_b + 0{\cdot}53 \pm 0{\cdot}13 \quad \ldots \text{(iv)}$$

by which the radius can be calculated from the absolute bolometric magnitude with a probable error of 13 per cent.

From equations (iii) and (iv), since $D \propto M/a^3$, we derive the relation

$$\log D = 0{\cdot}20\ M_b - 0{\cdot}97 \quad \ldots \text{(v)}$$

from which the density of a star can be calculated from its absolute bolometric magnitude.

7. *Interpretation of results.* In an earlier paper I have shown that a density—luminosity—temperature relation exists in the case of the pulsation variables, and that this relation is also satisfied for the visual binaries with well-determined masses (Bleksley 1937). This relation can be written in the form

$$\log D = 0{\cdot}48\ M_b + 5{\cdot}8 \log T \quad \ldots \text{(vi)}$$

From the definition of absolute bolmetric magnitude and effective temperature, the radius a of a star is given in terms of these quantities by the relation

$$\log a = -0{\cdot}20\ M_b - 2{\cdot}0 \log T \quad \ldots \text{(vii)}$$

From equation (i) in the foregoing, we also have the relation between temperature and absolute bolometric magnitude,

$$M_b = -20 \log T$$

From these equations and the relation $D \propto M/a^3$, we can derive four relations that should have considerable statistical significance:

$$\left.\begin{aligned} \log D &= 0{\cdot}19\ M_b \\ \log a &= -0{\cdot}10\ M_b \\ \log D &= -1{\cdot}9 \log a \\ \log M &= -0{\cdot}12\ M_b \end{aligned}\right) \quad \ldots \text{(viii)}$$

In equations (ii), (iii), (iv), (v) we have found statistical relations of this type, which for comparison are given here:

$$\begin{aligned} \log D &= 0{\cdot}20\ M_b \\ \log a &= -0{\cdot}11\ M_b \\ \log D &= -2{\cdot}0 \log a \\ \log M &= -0{\cdot}13\ M_b \end{aligned}$$

It will be seen that these agree very closely with the equations (viii) which are derived from the empirical density relation (vi). The present material therefore adds weight to the relation (vi) and induces one to extend it to give an empirical mass—luminosity—temperature relation.

8. *Mass—Luminosity—Temperature relation.* From equations (vi) and (vii), and the relation $D \propto M/a^3$, we can eliminate the density D and derive a relation connecting the mass M with the absolute bolometric magnitude and the temperature,

$$\log M = -0{\cdot}12\ M_b - 0{\cdot}2\ \log T \ldots \text{(ix)}$$

This equation is identical with a relation derived theoretically by Dr. J. K. E. Halm in an unpublished investigation, and agrees very well with the available observed masses of binaries. It will be discussed in greater detail in a later paper.

9. *Summary.* A statistical investigation of the density, mass, radius, absolute bolometric magnitude, and temperature of 46 component stars of eclipsing binary systems has been carried out. Coefficients of correlation between each pair of the above variables are given in Tables, and regression equations calculated for those variables for which the correlation is marked.

Given the absolute bolometric magnitude of a main series star, these regression equations enable us to calculate with fair accuracy and by very simple methods the mass, radius, and mean density of the star.

It is shown that the regression equations found can be derived from an empirical density—luminosity—temperature relation previously found for pulsation variables and visual binary stars. This relation leads to an empirical mass—luminosity—relation of very general applicability and accuracy.

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January, 1942.

NOTE ON THE STRAIGHT LINE OF BEST FIT FOR A SET OF COPLANAR POINTS

BY

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Read 30th June, 1941.

1. In many problems in experimental and statistical investigation, it is found necessary to determine a linear relation between two observational variables x and y. The standard procedure is based on the determination of regression lines by means of correlation or least-squares technique. In this method two equations are derived in the form

$$y-\bar{y}=a(x-\bar{x})$$

$$\text{and } x-\bar{x}=b(y-\bar{y})$$

where $\bar{x}$, $\bar{y}$ are the mean values of x and y respectively.

These equations are used to derive a value of y for given x and of x for given y respectively, and the values of the constants a and b are not reciprocal except in the case of perfect correlation between x and y. The first equation represents the line for which the sum of the squares of the deviations of y measured from the line is a minimum. The second equation corresponds to a minimum of the squares of the deviations of x from the line. The two equations are thus not strictly comparable, and can not be inverted.

For many purposes, however, it is convenient to have a single equation connecting x and y, by which it is possible to find either variable if the other is given. This corresponds to the very common graphical problem of drawing a straight line through a set of coplanar points. Such a line we will call a *line of best fit.*

In deriving the equation of such a line, it would be a considerable advantage to reduce the calculations necessary to such a form that they can be carried out at the same time as, and from the same data as required for, the determination of coefficients of correlation and of regression lines. In the present investigation the derivation of the equation of a line of best fit has been carried out, satisfying this desideratum.

2. Consider a system of coplanar points through which it is required to pass a line of best fit. We assume for simplicity that the variables are referred to their mean as origin. Consider any representative point P whose coordinates referred to the given rectangular axes are (x, y). Let OL making angle θ with the x-axis be the line of best fit, and let OM be a line in the plane perpendicular

to *OL*. Let the coordinates of *P* referred to *OL*, *OM* as axes be (ξ, η). Then we can transform from coordinates (x, y) to (ξ, η) by the equations

$$\xi = x \cos\theta + y \sin\theta$$
$$\eta = y \cos\theta - x \sin\theta$$

We define *OL* as the line of best fit if $\Sigma\eta^2 = \text{minimum}$

$$\text{i.e.,}\quad \Sigma\frac{d}{d\theta}[y\cos\theta - x\sin\theta]^2 = 0 \qquad \text{(i)}$$

This equation can be reduced to the form

$$\tan^2\theta.\ \Sigma xy + \tan\theta.\ \Sigma(x^2 - y^2) - \Sigma xy = 0$$

from which

$$\tan\theta = \frac{-(\Sigma x^2 - \Sigma y^2) \pm [(\Sigma x^2 - \Sigma y^2)^2 + 4(\Sigma xy)^2]^{\frac{1}{2}}}{2\,\Sigma xy} \qquad \text{(ii)}$$

The values of θ given by (ii) are those for which (i) holds, and thus represent the position of *OL* for $\Sigma\eta^2$ to be either a maximum or a minimum. The product of the two possible values of *tan* θ is -1, so that the directions thus found are mutually perpendicular. By the usual methods it is simply proved that the position of the axis *OL* for a minimum value of $\Sigma\eta^2$ is that for which the $+$ sign is taken in the solution (ii).

An alternative and sometimes useful form of the result can also be obtained from (i) by simple reduction, namely

$$\tan 2\theta = \frac{2\,\Sigma xy}{\Sigma x^2 - \Sigma y^2} \qquad \text{(iii)}$$

This equation gives two values of θ corresponding as before to mutually perpendicular directions. The choice of the correct value in any given case is never difficult, since it is obvious from inspection whether the required line lies in the first and third quadrants, or in the second and fourth.

3. If the variables are measured from some origin other than the mean, so that the mean has coordinates $(\bar{x}, \bar{y})$ referred to the given axes, we choose a line *GL* passing through the mean point *G*, and inclined as before at angle θ to the axis of x. Then the transformation to coordinates (ξ, η) referred to *OL*, *OM* as axes is given by

$$\xi = (x - \bar{x})\cos\theta + (y - \bar{y})\sin\theta$$

$$\eta = (y - \bar{y})\cos\theta - (x - \bar{x})\sin\theta$$

The condition for best fit is as before

$$\Sigma\eta^2 = \text{minimum}.$$

By definition $\bar{x} = \Sigma x/N$, $\bar{y} = \Sigma y/N$, where N is the number of points. Using this definition and applying the process used before, we find θ given by the equation

$$\tan\theta = \frac{-(N\sigma_x^2 - N\sigma_y^2) \pm [(N\sigma_x^2 - N\sigma_y^2)^2 + 4P_{xy}^2]^{\frac{1}{2}}}{2P_{xy}} \qquad \text{(iv)}$$

where

$$N\sigma_x^2 = \Sigma x^2 - Nx^2$$

$$N\sigma_y^2 = \Sigma y^2 - N\bar{y}^2$$

$$P_{xy} = \Sigma xy - N\bar{x}\bar{y}$$

An alternative form for θ is given by

$$\tan 2\theta = \frac{2[\Sigma xy - N\bar{x}\bar{y}]}{N\sigma_x^2 - N\sigma_y^2}$$

It will be seen that the quantities needed for the determination of the line of best fit are x^2, y^2, xy, x, y. These are also the quantities needed for the calculation of coefficients of correlation and the equations to the regression lines, so that one set of computations enables us to obtain these as well as the equation to the line of best fit. It is clear that the line of best fit will always be intermediate to the two regression lines.

4. In order to determine the goodness of fit, let us compute the quantities $\Sigma\eta^2$ and $\Sigma\xi^2$. Thus we have

$$\begin{aligned}\Sigma\eta^2 &= \Sigma(y\cos\theta - x\sin\theta)^2\\ &= A\cos^2\theta + B\sin^2\theta\\ &\qquad -2D\sin\theta\cdot\cos\theta \end{aligned} \qquad \text{(v)}$$

and in the same way

$$\begin{aligned}\Sigma\xi^2 &= A\sin^2\theta + B\cos^2\theta\\ &\qquad +2D\cos\theta\cdot\sin\theta \end{aligned} \qquad \text{(vi)}$$

where $A = \Sigma y^2$, $B = \Sigma x^2$, $D = \Sigma xy$ (vii)

If we write $\Sigma\eta^2 = N\sigma^2$ and $\Sigma\xi^2 = N\rho^2$, the quantity σ can be regarded as a measure of the goodness of fit, but is dependent on the scale. As a measure of the goodness of fit, therefore, we calculate the ratio σ/ρ.

In the case of a circular distribution of points, it is obvious that $\sigma/\rho = 1$, while in the case of a rectilinear distribution, $\sigma/\rho = 0$. Hence as the coefficient of linear correlation varies between 0 and 1, the coefficient of fit, σ/ρ, varies between 1 and 0. The ratio is independent of the scale, and is therefore suitable for the purpose for which its use is suggested.

5. As an example of the application of the method, let us consider some of the data of my paper on the statistics of density, mass, and radius of 46 eclipsing binaries presented at this meeting of the Association. From Table V. of this paper, we extract the data for $x = a$ (bolometric absolute magnitude) and $y = z$ (logarithm of the radius). We find $N = 46$, $\bar{x} = -0.697$, $\bar{y} = 0.530$, $\Sigma x^2 = 488.36$

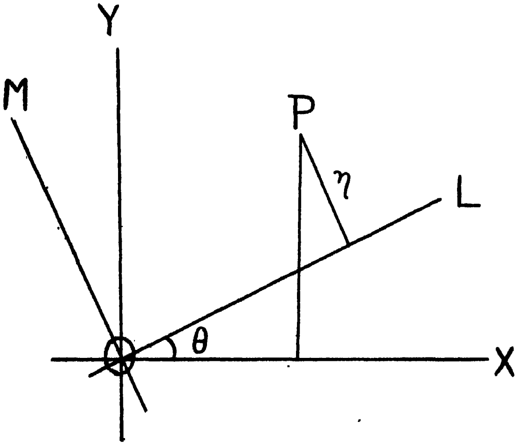
$\Sigma y^2 = 21.97$, $\Sigma xy = -76.09$. On substituting these values in equation (iv) and taking the correct root, we find the line of best fit given by

$$\tan\theta = -0\cdot 13.$$

The equation to the line is therefore $z = -0\cdot 13a$, or $a = -7\cdot 7z$, where z and a are measured from their means as zero.

From equations (v) and (vi) (corrected in the usual way for the origin not at the mean) we calculate $N\sigma^2$ and $N\rho^2$ finding the values $N\sigma^2 = 1\cdot 00$, $N\rho^2 = 466\cdot 4$. Hence the coefficient of fit, $\sigma/\rho = 0\cdot 047$. This low value points to a high degree of linear correlation between the two variables, and a close representation of the points by the line whose equation we have determined above.

6. *Summary.* A statistical technique for finding a line of best fit for a system of coplanar points is described, and applied to an example. A measure of the closeness of fit is derived.



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THE PHYSICAL PROPERTIES OF THE ESTUARINE AND MARINE CLAYS OF THE PORT ELIZABETH AREA

BY

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Read 30th June, 1941.

Towards the end of 1938, the clay deposits of the Eastern Province were visited and examined. The estuarine and marine clays of the Uitenhage Series of the Port Elizabeth area were found to differ from any of the clays previously investigated. These notes contain data which have so far not been available. With the exception of the field work by Haughton (1) very little attention has been paid to these rather remarkable rocks.

The data incorporated in this paper can be dealt with as follows: 1. Size analyses. 2. Petrography. 3. Modulus of rupture.

1. *Size analyses.*

These were done by the sieve and pipette methods used in previous investigations.(4) The clays in general slake easily in water and no harsh treatment was required to break up the materials into their component parts. In tables 1 and 2 analyses show that all the clays contain only a small proportion of coarse but quite a lot of fine sand. The amount of " clay," i.e. " inorganic colloid," is high. Other points of interest are the angular nature of all the quartz grains and the comparatively rare appearance of kaolinite. Felspars are also not very common. These mechanical analyses were not very illuminating from the point of view of particle size and rather more detailed work was subsequently done; see Tables 3 onwards.

TABLE 3.

D.61 Green Clay, Despatch.

	% by weight
Over 4 mm.	2·10
4-2 mm.	0·04
2-0·2 mm.	2·14
0·2-0·14 mm.	16·22

Fine sand	30·76
Silt	20·92
Clay	28·64
H_2O	2·46
Solution Loss	tr.
	103·28

The accessory minerals larger than the fine sand fraction were mainly quartz and occasionally felspar.

A yellow clay from the Eastern Province Cement Co. quarry had the size distribution shown in Table 4.

TABLE 4.

D·35	% by weight
Plus 4 Mesh Tyler (4·7 mm.)	nil
,, 10 ,, ,, (1·65 mm.)	nil
,, 65 ,, ,, (0·21 mm.)	3·04
,, 200 ,, ,, (0·074 mm.)	33·86
,, 325 ,, ,, (0·043 mm.)	10·24
Fine sand	18·01
Silt plus clay	42·16
-H_2O	1·91
Solution loss	0·72
	109·94

On the addition of hydrogen peroxide a violent reaction took place, lasting about half an hour.

Another red clay which had a rather variegated appearance had the following size distribution.

TABLE 5.

D·41 Port Elizabeth.	
Plus 4 Mesh Tyler	nil
,, 10 ,, ,,	nil
,, 65 ,, ,,	1·05
,, 200 ,, ,,	7·50
,, 325 ,, ,,	4·95
Fine sand	1·44
Silt plus clay	76·20
-H_2O	4·13
	95·27

It is clear that whatever sand is present is certainly not coarse and that the clays are in general very fine grained. In fact the accessory quartz, etc., is really in the form of "flour" and the proportion of coarse material is indeed very small. Low stream velocities or fairly deep water conditions must have prevailed. Only occasionally do the clays become at all "sandy," i.e. containing say 10-20% material of plus 65 mesh. Qualitatively the rocks may be said to vary from medium to very fine grained.

2. *Petrography.*

One noticeable fact about these clays is that they are often gypsiferous. In fact, at Uitenhage a vein of gypsum was observed cutting diagonally through the red clays. No doubt this is of common occurrence but was not specially looked for. In a previous paper the striking repetition of red and blue clays has been shown. The other varieties of yellow and grey are less common.(²) Often the laminations are just as distinct under the microscope. Fig. 1 shows this. In Fig. 2 the very angular nature of the quartz is evident. The large shreds are of kaolinite and are very similar to those noticed in the fireclays at Boksburg.(³)

As regards the mineralogy Dr. R. E. Grim examined some specimens by X-ray diffraction methods and reported as follows:—

> "The grayish-blue clay from near Port Elizabeth contains a small amount of kaolinite and a clay mineral that closely resembles illite. This second clay mineral resembles illite, but positive identification would require further study. The general characteristics of this clay such as its colour and fracture are exactly like those clays in the coal measures of Illinois that occur directly beneath beds of coal."

The main accessory minerals are quartz, ilmenite, felspars and gypsum. The identification of the ferruginous minerals has not been made, but the difference between the red and green types appears to lie in the state of oxidation of the iron, i.e. whether as ferrous or ferric compounds; although factors as yet not ascertained may affect this condition. Oxidation at low temperatures and under aqueous conditions does not change the colour of the green clays. Another feature observed is that while the colour of the red clays is hardly affected by drying, the green and blue varieties become a dirty greyish colour on desiccation. On heating to temperatures over 700 to 800° C. the green and blue coloured clays all become red. In chemical composition there is very little difference between the two varieties.

3. *Modulus of Rupture.*

These clays are remarkable for the high values of the modulus of rupture. Generally speaking the red coloured types are stronger than the green or blue ones. In table 6 some characteristic values are given. All the briquettes were prepared by hand in a small wooden mould and carefully dried to 110° C.

TABLE 6.

Specimen No.	Nature of Clay	Locality	Modulus of Rupture in lbs. per sq. in.
D.35	Light brown	Port Elizabeth	444
36	Greenish yellow		288
36 A	Greenish yellow		462
37	Deep red		608
38	Light green		246
39	Dirty white		193
41	Chocolate buff		307
42	Dirty green		466
50	Red	Redhouse	390
27	Light greenish blue	Aloes	146
53	Hard red	Redhouse	360

CONCLUSIONS.

From these results it is evident that the marine and estuarine clays in this area possess some remarkable qualities. In fact the vast amount of ceramic data accumulated in the research suggest that good quality building bricks, roofing and floor tiles can be made from these clays. The method of manufacture must, of course, be suitable and good kilns, grinding and pressing equipment are necessary.

ACKNOWLEDGMENTS.

I am indebted to Dr. R. E. Grim for the X-ray examinations. Prof. G. H. Stanley gave valuable advice during the early stages of the work. Mr. J. J. Frankel very kindly prepared the photomicrographs, while I was away on active service.

SUMMARY.

The marine and estuarine clays of the Port Elizabeth area were examined physically. They differ in character from the clays of other parts of the Union of South Africa. Illite is reported for the first time in South Africa. From the ceramic point of view the clays are of quite high quality.

TABLES 1 and 2: MECHANICAL ANALYSES.

Size Fraction	D.37. Red Clay, East'n Province Cement Co., Port Elizabeth		D.50. Red Clay, Vee-plaats, near Redhouse		D.27. Light greyish-blue plastic clay. Aloes.		D.53. Hard Red Clay, Klein Skool, near Redhouse.	
	% by Wt.	Microscopic Examination	% by Wt.	Microscopic Examination	% by Wt.	Microscopic Examination	% by Wt.	Microscopic Examination
Coarse Sand 2·0 mms. to 0·2 mms.	Nil.		4·30	Abundant discrete quartz, but also ferruginous siliceous particles rather porous	tr.		1·20	Small amounts of Quartz, mainly reddish brown, translucent particles, isotropic.
Fine Sand 0·2 mms. to 0·02 mms.	0·30	Fair amount of discrete quartz, much of it 20-25 microns in diameter	24·80	Mainly quartz and oxides of iron. Quartz grains rather angular	1·07	Mainly Quartz	20·0	
Silt 0·02 mms. to 0·002 mms.	31·40		35·80		75·56	Mainly Quartz	39·90	Abundant clear quartz, plagioclase and pyrophyllite (?)
Clay 0·002 mms.	58·50		28·80		23·40		33·90	
Moisture — 110°C.	4·63		3·57		3·47		3·11	
Total ...	94·83		97·07		103·50		98·11	
Notes—	Soluble material not taken into account.		Nearly 2 per cent. material soluble in warm HCl.		On wetting, clay becomes distinctly green in colour.			

Any gypsum in these clays is leached out before mechanical analysis is done.

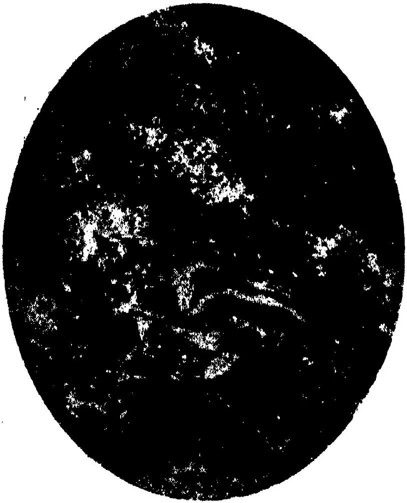

Fig. 1. Soft red clay Uitenhage. Plane Polarised light. Fine laminations in lower portion. In the upper portion a large irregular shred of Kaolinite is visible. X 17.5

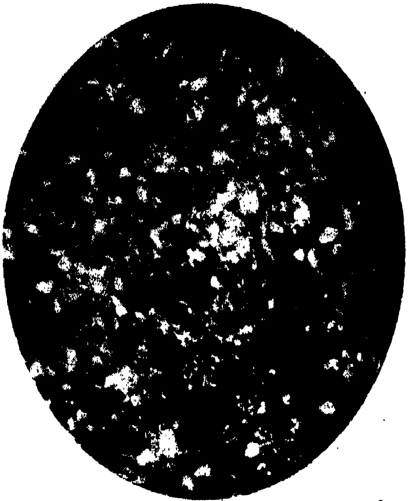

Fig. 2. Green Clay, Klein Skool. Crossed Nicols. Note very angular character of the quartz. X 26.

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SOME FACTS AND FALLACIES ABOUT THE VITAMINS

BY

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Read 1st July, 1941.

ABSTRACT.

In conjunction with an exhibit of the principal known vitamins, the main claims to importance for this remarkable group of substances were outlined, and the new insight they are providing with respect to the chemical processes that take place in the human body was stressed. Some of the directions in which future progress may be expected were suggested, and after dealing with a few of the commonly held fallacies regarding the vitamins, an account of some remarkable experiments carried out recently in America were discussed.

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CHROME-BEARING MAGNETIC ROCKS FROM THE EASTERN BUSHVELD

BY

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Read 30th June, 1941.

While collecting samples of chromites for the Minerals Research Laboratory with Dr. J. Gelletich, he drew my attention to a composite chromite-"magnetite" rock occurring a small distance below what is presumably the Merensky Reef on the farm Tweefontein 35, Lydenburg district. The rock lies above the upper group of chromitites in two bands, the upper one two to three feet thick and the lower six feet thick.

Two types of material are clearly distinguished in hand specimens. One a coarse-grained almost silicate-free portion which merges into the other, a mixture of finer-grained chromite and pyroxene. The former type is strongly magnetic, whilst the chromite is non-magnetic.

At first, when examining polished sections of the composite rock under the microscope, the coarse-grained portion would appear to be steel-grey in colour, practically the same as the finer-grained chromite. If, however, a comparison is made of the two types by moving the section rapidly from the coarse to the finer portion, a slight colour difference becomes apparent and the former then has a very faint touch of rose-brown, similar to that of magnetite.

The largest grains in the magnetic material are just over one m.m. across, the average diameter being 0·5 m.m., while smaller grains are not abundant. There is only a small percentage of interstitial pyroxene. At 5·0 m.m. away from the obviously non-magnetic chromite, ilmenite becomes fairly abundant as subhedral grains up to 1·2 m.m. across, as triangular areas and as broad and also minute laths (fig. 2). High power shows that some of the ilmenite is in graphic intergrowth with and bordered by an unidentified light blue mineral which is resistant to etching reagents (fig. 3).

Although the colour and isotropic nature of the magnetic material are the same as those of magnetite, the reactions to etching reagents are vastly different. Only those areas farthest away from the chromite etch easily with $SnCl_2$ in HCl and, after several minutes with concentrated HCl. As the chromite is approached neither of these reagents produces any effect. On such material, however, fuming perchloric acid has a vigorous effect, removing the polished surface without producing any suggestion of an etch pattern as in the case of chromite. Highest powers reveal no visible intergrowth of minerals.

Small circular and oval grains of pyrite 0·01 to 0·03 m.m. across occur in the centres of the magnetic grains. Goethite is present, more particularly in weathered specimens, in intergranular spaces and veinlets down to 3μ wide bordering and cutting across the ilmenite and magnetic mineral. Occasionally a small intergrowth of martite in widmanstätten arrangement with the main material is present along cracks.

The non-magnetic part of the rock may be described as a friable chromite with polygonal and rounded steel-grey isotropic grains of average diameter 0·25 m.m., interspersed in pyroxene. Only fuming perchloric acid produces any etch effect. Even under highest powers there is no visible intergrowth.

From the microscopic examination there is evidence of a gradation from a chromite to a mineral resembling magnetite and which is probably a chrome-magnetite.

It was possible to break off pieces of the rock containing practically no chromite and also others containing no magnetic material. These two fractions were finely crushed and superpanned to remove gangue. Magnetic treatment removed ilmenite and chromite in one case and freed the chromite from the magnetic grains in the other. It was realised that the magnetic fraction contained variations from grains near the chromite proper to those more highly magnetic grains farther away. Likewise some non-magnetic "transition" material was very possibly included with the chromite.

Analysis of the magnetic fraction gave the following:

SiO_2	0·10
Al_2O_3	9·22
Fe_2O_3	29·03
FeO	34·90
MgO	0·25
CaO	none

Total H_2O	0·08
TiO_2	12·80
Cr_2O_3	12·34
V_2O_3	none
MnO	none
	98·72

Analysts
G. W. Grainger and J.J.F.
Specific Gravity 4·53

This shows no marked similarity to any published analysis of other Bushveld iron ores. Although there is a high content of ferrous oxide, the excess of that constituent over ferric, chromic and titanium oxides may be satisfactorily allocated to alumina which for this purpose could be considered to replace chromic oxide. The chromic oxide and titania must be in some combination other than as free chromite and ilmenite, which in any case must have been substantially removed from the sample prepared for analysis. There is the possibility that the titania may be present in a submicroscopic intergrowth of ilmenite in the magnetic material.

The powdered sample dissolves fairly readily in hot concentrated HCl, except for a small amount which is taken into solution only after several hours. A small quantity of this apparently more resistant material was examined in polished section. It did not exhibit any peculiar features and was found to contain 16·2% Cr_2O_3.

The chromic oxide content of the magnetic material decreases with distance from the chromite and in two samples about two cms. away from the latter, value of 6·84 and 9·3% Cr_2O_3 were obtained. In the case of the latter sample, the ferric oxide was 36·8% and the ferrous oxide 27·2%. No trace of chromite was found and etching with concentrated HCl produced a light brown stain fairly rapidly.

In cases where the magnetic portion of the rock has been converted into earthy limonite, only remnants of the original constituents are seen, and apparently all the chromium has been removed, for a determination gave only a faint trace thereof.

From the evidence presented it would seem that the magnetic mineral is a complex spinel which grades with decrease of iron and titanium into a "chromite" spinel.

The chromite fraction has a specific gravity of 4·52, the same as that of the magnetic mineral. It contains 35·32% Cr_2O_3 and 37·9% total iron, calculated as ferrous oxide A direct determination of ferrous iron by treatment with H_2SO_4

and HF and titration with permanganate gave 5·35% FeO. After boiling for several hours with concentrated HCl only 0·9% of iron was taken into solution. The percentage of mineral dissolved in H_2SO_4—HF, suggests that a small quantity of "transition" material was present, a point strengthened by the high total iron content.

In the same area farther down the hill, there occurred in the pyroxenite a few inches above a series of chromitite bands, small nests of a coarse-grained magnetic rock up to two inches thick. In polished section the rock is seen to be made up of embayed grains, averaging 0·7 m.m. to 1 m.m. across, of a pale greyish rose-brown mineral, very slightly anisotropic and polygonal grains of ilmenite up to 1·5 m.m. across. These are set in pyroxene both monoclinic and orthorhombic having optic angles of 46° to 51° (—) and 70° (+) respectively. From orientated thin sections, the optic axial plane was found in the latter mineral to be perpendicular to the pseudo-stratification of the various surrounding pyroxenites and chromitites.

Concentrated HCl etches the magnetic mineral after a few minutes and $SnCl_2$ in HCl rapidly darkens the grains. Under high power there is revealed on etching a fine intergrowth of unetched laths very often less than 0·5μ wide in a widmanstätten pattern or haphazardly arranged in the etched portions (fig. 4). In more compact portions of the rock, the magnetic grains are more polygonal in shape up to 1·5 m.m. across, enclose small rounded particles of pyroxene and are very often bordered by a zone of graphic-like intergrowths of itself and pyroxene, (fig. 5). Close examination shows that here the pyroxene is replaced and areas are abundant where such replacement is almost complete.

Analysis gave Fe_2O_3 46·7%, FeO 31·6% and Cr_2O_3 6·19%. No visible chromite was detected and the powder dissolved fairly rapidly in hot concentrated HCl. This rock differs from the one described above by the presence of clear intergrowths revealed on etching. Further, this rock was not seen to grade into a chromite.

The presence of chromite-magnetite rock on the farm Haakdoorndrift has previously been recorded (1). A coarse-grained titaniferous magnetite collected by Dr. Gelletich and the writer from just above chromitites on this farm, revealed no peculiar features—the chromic oxide percentage was not high (2).

A chrome-rich magnetite associated with chromitites from the Western Bushveld (Groenfontein 302) has been analysed and described briefly (3). Although the analysis shows some chemical similarity to the rock described above, it appears to be a chromitite rather than a magnetite rock. It is much less magnetic than the Eastern Bushveld rock and in polished section it is seen to be composed of much ilmenite interstitial to and in laths penetrating the steel-grey isotropic chromite. The chromite is very resistant to fuming perchloric acid but an etch effect is produced after prolonged treatment, which does not resemble that of normal chromite.

ACKNOWLEDGMENTS.

I thank the Director and Committee of the Minerals Research Laboratory for permission to publish this paper. Mr. G. W. Grainger and Mr. R. Baskind kindly assisted with the analytical work. My thanks are due to Dr. J. Gelletich for showing me this interesting occurrence, and to Professor B. V. Lombaard for giving me a sample of Groenfontein magnetite.

SUMMARY.

Chrome-bearing magnetic rocks from the Lydenburg district are described. Analytical data are given and it is suggested that in one case there is a transition from chromite to a complex mineral resembling magnetite.

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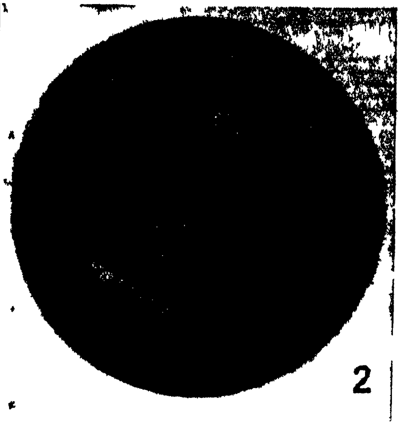

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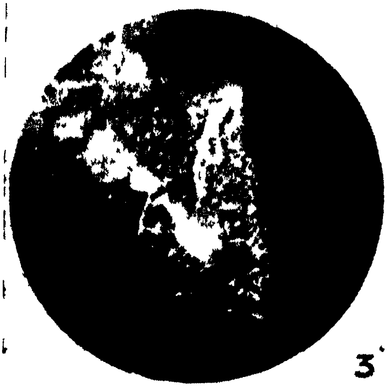

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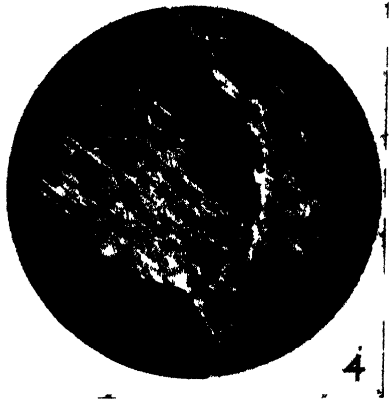

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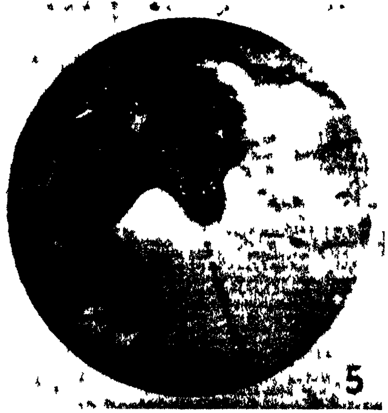

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Fig. 1. Photomicrograph showing coarse-grained magnetic portion of rock grading into finer chromite which is associated with much pyroxene. X10.

Fig. 2. Ilmenite(light) distributed in magnetic material. Nicols partly crossed. X24.

Fig. 3. Intergrowth of Ilmenite(white) with unidentified Light blue mineral(grey) in magnetic material. X800.

Fig. 4. Etched surface revealing fine orientated laths of Ilmenite. X600.

Fig. 5. Replacement of Pyroxene by magnetic mineral(white). X80.

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THE ASSIMILATION AND RESPIRATION RATES OF SOME NATAL GRASSES

BY

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Read 1st July, 1941.

Introduction.

The study of carbon assimilation is one which has received but little attention in South Africa. An attempt is here made to investigate this problem as regards a few selected grass types, a problem not without importance in a country where grasses and grasslands comprise one of its most valuable assets. The method adopted for measuring the rate of assimilation or respiration was based on the measurement of changes in the carbon dioxide concentration of a closed system, a Haldane gas analysis apparatus being used for this purpose. As it was required in the first place to ascertain whether the apparatus adopted was well suited for the measurement of assimilation and respiration in grasses, and since the construction, testing and improvement of the somewhat complex apparatus absorbed a not inconsiderable portion of the available time, the nature of the research undertaken had of necessity to be that of a preliminary investigation.

Description of the Apparatus.—In its essentials, the apparatus consisted of a receptacle for the grass leaves, a circulating pump, a reservoir of about 1500 ccs. capacity to increase the total volume of the system, and the Haldane apparatus connected by a T-tube with the system.

Haldane apparatus.—The Haldane gas analysis apparatus of the larger type designed for general air and gas analysis was used for the measurement of the carbon dioxide concentration, and the instructions of Haldane (Haldane, 1920) were followed with regard to its manipulation and management. In making up the caustic potash solution the additional instructions given by Bolas (Bolas 1926) were followed.

Circulating pump.—The Circulating pump was of the type described by Leach (Leach 1930). At first it failed to function correctly for any length of time, but after a number of minor alterations had been made it proved satisfactory. From a measurement of the rate at which the pump functioned, it was calculated that about ten minutes was required for the air in the system to pass through a complete circuit. The air in the system after leaving the circulating pump passed through a glass bulb which acted as a kind of buffer, preventing the pressure (and hence the resistance) from rising unduly high after each blast of air was forced from the pump.

Receptacle for the grass leaves.—The receptacle for the grass leaves consisted of an ordinary wash-bottle, which enabled quite good spacing of the leaves to be obtained. A thermometer was held in position within the wash-bottle by means of rubber bands. The container was placed on a window-sill so that the leaves were under natural conditions of illumination; it was, however, surrounded by a water jacket which prevented an excessive rise in temperature.

Reservoir.—For the sake of accuracy it was found necessary to use a rather small reservoir (of about 1500 ccs. capacity), which resulted in quite a considerable alteration in the carbon dioxide concentration being produced by the assimilatory or respiratory activity of the plant. This produced however the disadvantage that the leaves were surrounded by an atmosphere in which the carbon dioxide concentration was continually changing. As is later pointed out, this need not necessarily prove a serious objection.

It was found that variations in temperature during the course of the day altered the pressure of the air within the system quite considerably, and this in turn affected the mercury levels of the circulating pump, preventing it from functioning. In order to overcome this difficulty the reservoir together with a flask outside the system were partly filled with a saturated and slightly acidified solution of sodium chloride and sodium sulphate, and the two connected together by means of a siphon. Consequently any increase or decrease in pressure was largely compensated for by an automatic change in the capacity of the system. The above solution was used as it did not absorb carbon dioxide. The air after leaving the reservoir was dried by being passed over calcium chloride; this was necessary as damp air interfered with the working of the valves of the circulating pump. The total capacity of the system was 2300 ccs.

Procedure adopted during experiments.—Before the commencement of an experiment, it was necessary that the carbon dioxide concentration of the air in the system should be suitable—carbon dioxide could if required be added from a Kipp's apparatus. Grass leaves (which had been cut under water) were introduced into the system, and the temperature and barometric pressure noted. The system was then closed and the circulating pump started. An interval (half-an-hour or more) was allowed for thorough mixing of the air to take place, and no analyses were made till then.

Analyses of air were usually made at hourly intervals. Each time a sample of air was withdrawn for analysis, the reading of the thermometer in the container for the grass leaves was noted. Twenty or thirty minutes were allowed for a complete analysis in order to ensure that the air became saturated with water vapour, and that all carbon dioxide was absorbed. After the completion of each analysis the air was returned to the system, so that the total volume of the air should not be seriously affected.

Before the conclusion of an experiment, the respiration rate was found. The leaves were placed in the dark by covering up the water jacket surrounding the container with a large piece of black paper or cloth care being taken to exclude all light. It was then no longer

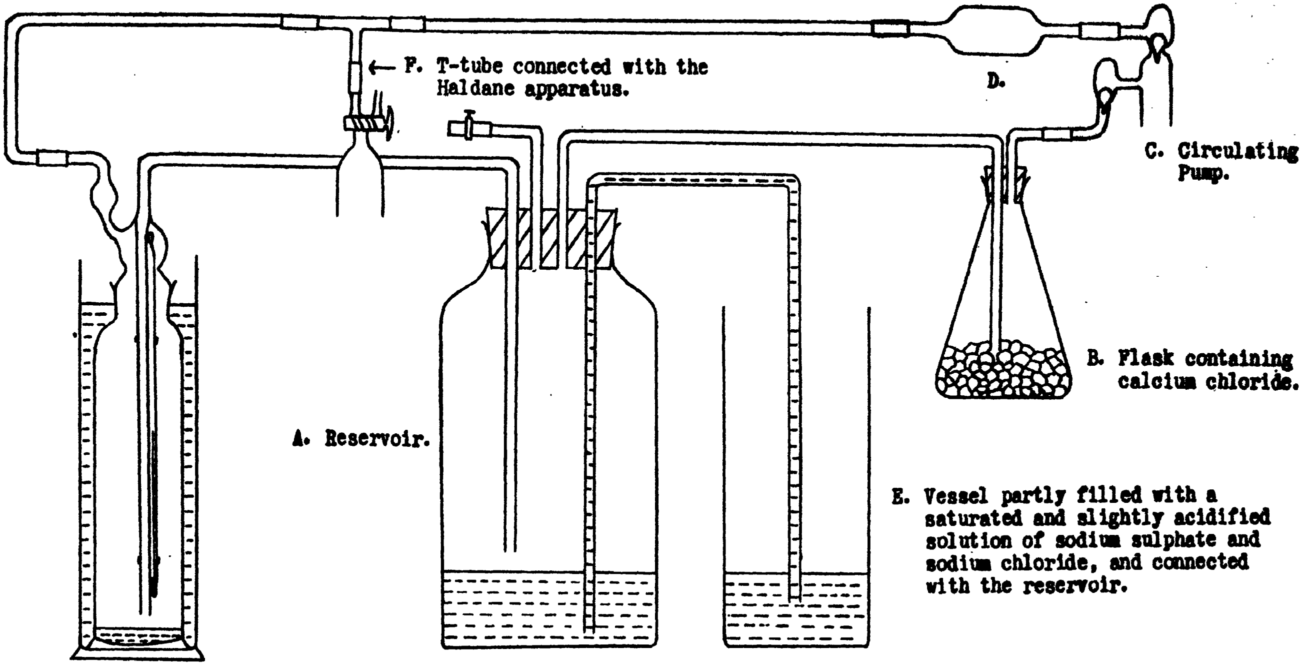

F. T-tube connected with the Haldane apparatus.
D.
C. Circulating Pump.
B. Flask containing calcium chloride.
A. Reservoir.
E. Vessel partly filled with a saturated and slightly acidified solution of sodium sulphate and sodium chloride, and connected with the reservoir.
G. Receptacle for grass leaves, containing a thermometer and surrounded by a water jacket.

DIAGRAM I.

Diagram of the completed apparatus.

possible to read the thermometer in the container for the leaves, and the temperature of the water surrounding the latter had to be taken. It was, however, found that these temperatures (of the air within the container and of the water surrounding it) corresponded closely.

In calculating the rate of assimilation, allowance for the respiration rate was always made.

To find the surface area of the leaves used in the experiments, prints on photographic printing paper were made of a number of them, and their area found by means of a planimeter. Their dry weight as well as the dry weight of the rest of the leaves was found, and the total surface area then calculated.

GENERAL CONCLUSIONS REGARDING THE VALUE OF THIS TYPE OF APPARATUS.

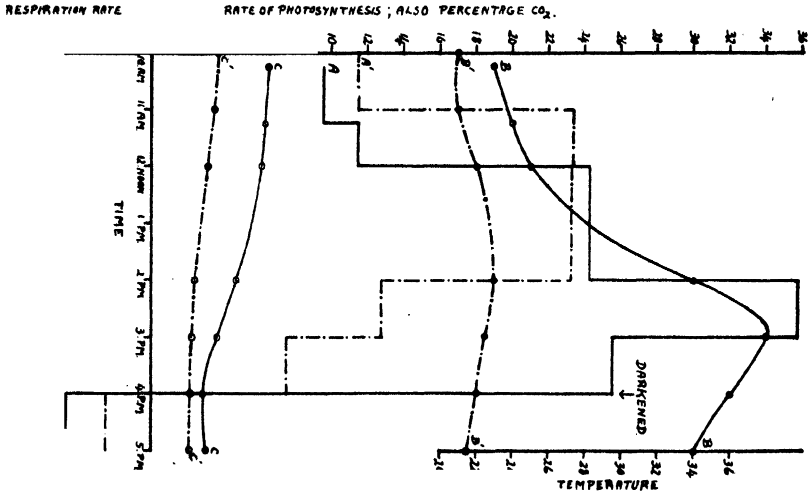
In a work of this nature, where an attempt is made to investigate the specific rates of assimilation of certain plants rather than the phenomenon of photosynthesis in general, the ideal method to be adopted would be to measure assimilation rates under conditions as closely approximating to the natural as possible; and to perform dual experiments so that a comparison could be obtained between different plants when under similar or the same conditions. With the type of apparatus used in this work, it is not possible to measure assimilation under natural conditions, as the carbon dioxide concentration has to be increased to a value considerably greater than that normally present in the atmosphere.

The disadvantage common to all types of apparatus involving the principle of a closed system, namely changes in the carbon dioxide concentration of the air surrounding the plant, naturally applies here. This, however, is not so grave a disadvantage as might at first appear, since the carbon dioxide concentration is always accurately known, and if it varies between certain limits only, a change exerts no profound influence upon the plant, as other factors are limiting the process of assimilation. In this work it was necessary to use excised leaves which have been found to have a higher rate of photosynthesis than attached leaves. (Spoehr 1926). In spite of these disadvantages, the apparatus finally proved an accurate means of measuring photosynthesis, and should be of value, especially where facilities exist for maintaining temperature and light intensity constant.

THE PLANTS INVESTIGATED.—The grasses investigated comprised the following species, viz.: *Themeda triandra* var. *glauca*, *Themeda triandra* var. *trachyspathea*, *Eragrostis curvula*, *Tricholaena rosea*, *Panicum maximum*, *Aristida junciformis*. In addition to the above grasses, a comparison was made with two types of associated plants of the grasslands—*Hypoxis rooperi* and *Senecio bupleuroides*. In both these plants the leaves were similar to grass leaves in shape, and were therefore exposed to similar conditions during experiments.

DISCUSSION.

In spite of the fact that the grasses investigated were of different ecological types, they showed great uniformity of behaviour with regard to their assimilatory and respiratory activities. The two associated plants of the grassveld on investigation were similar to the grasses in their metabolic behaviour. A detailed individual account of each experiment is therefore unnecessary, and general conclusions only will be given.



Graph I.

Curve (A-A)—The rate of assimilation or respiration of *Tricholaena Rosea* on a fine day in mgms. per sq. dcm. per hour.

Curve (B-B)—Temperature in degrees Centigrade.

Curve (C-C)—CO_2 concentration in percentage.

Graph II.

Curve (A′-A′)—the rate of assimilation or respiration of *Eragrostis curvula* on a cloudy day in mgms. per sq. dcm. per hour.

Curve (B′-B′)—Temperature in degrees Centigrade.

Curve (C′-C′)—CO_2 concentration in percentage.

(a) *Relative importance of the factors temperature and light intensity with regard to the results obtained*

In general the graphs for temperature and rate of assimilation show a fairly close correspondence, both rising to a maximum at or around midday and then later falling off. (Graph I is presented as an example). A number of workers have reported a midday minimum for the assimilation rate, but their experiments were apparently carried out under more natural conditions than was here the case, and the phenomenon may possibly have been due to a direct or indirect effect of low water content. The correspondence between temperature and rate of assimilation might appear to indicate that temperature was the limiting factor of the process. On the other hand, light intensity will in general follow a similar course to that of temperature, and hence the relation between temperature and rate of assimilation may be only apparent, the real correspondence lying between the latter and light intensity.

Although most of the evidence at present available would suggest that a light intensity of full sunlight is more than sufficient for the highest rates of photosynthesis possible at a temperature above 25° C., when the supply of carbon dioxide is not limited, this fact is not conclusively established. Maximov for instance states that in those plants peculiar to open sunny habitats, assimilation increases until the intensity of light has attained the intensity of full sunlight. (Maximov 1930).

From the results obtained during these experiments, it is not possible to say whether light was a limiting factor under conditions of direct sunlight. It seems likely, however, that light became a limiting factor when the intensity of direct sunlight was reduced even slightly. In Table I are given some results having a bearing on this matter.

TABLE I.

Rates of assimilation under varying conditions of light intensity but similar conditions of temperature.

No. of Expt.	Name of Grass.	Time.	Temp. in deg. C.	Percent. of CO_2	Real assimltn. in mgms./sq.dcm./hr.
45	*Tricholaena rosea*	2–3 p.m.	41–42	10·2–9·2	33·3
		3–4 p.m.	42–41	9·2–8·8	13·0
50	*Tricholaena rosea*	2–3 p.m.	34–38	4·7–3·6	35·8
		3–4 p.m.	38–36	3·6–2·8	25·6
46	*Aristida junciformis*	2–3 p.m.	37–40	5·1–4·4	29·0
		3–4 p.m.	40–36½	4·4–3·9	21·8

It will be seen from Table I that the assimilation for the three experiments given was considerably lower during the period 3-4 p.m. than that during the previous hour. It seems likely that this is to be accounted for by the decrease in light intensity which was observed to occur during the second period. On the other hand it is possible that the rather high temperature to which the leaves had been exposed might have resulted in a lowering of the rate of assimilation.

From the results obtained it seems clear that when the leaves were not exposed to direct sunlight, as was the case with experiments performed on cloudy days or during the time before the sunlight reached the leaves on clear days, light intensity was a limiting factor; under these conditions an increase in the light intensity always resulted in an increase in the rate of assimilation. Graph 2, constructed from results obtained on a cloudy day, is typical.

(b) *Effect of carbon dioxide concentration.*

It would appear that as a general rule the carbon dioxide concentration was sufficiently high not to act as a limiting factor unless the concentration was considerably reduced by the assimilatory activity of the plant. This is shown by the marked response of the plant to light intensity which could not have occurred had the carbon dioxide concentration been limiting to any extent.

From one or two experiments made with *Themeda triandra* var. *trachyspathea* it appeared that a concentration of about 6% was sufficiently high to exert a toxic or narcotic effect, while a concentration of 8% resulted in a very low rate of assimilation under otherwise favourable conditions.

(c) *The question of an absorbing substance.*

In some experiments carried out at the beginning of this work, a higher rate of assimilation was recorded for the first period than for those following, although temperature and light intensity were increasing; in others the initial rate was higher than would be expected when such factors as temperature and light intensity were taken into account. Table II is presented as an example.

TABLE II.

Rates of assimilation and respiration of *Eragrostis curvula.*

	Time.	Percentage of CO_2	Temp. in degrees C.	Real assimltn. or respn. in mgms. per sq. dcm. leaf surface per hour.
Assimilation	11 am..-12n.	3·6—3·0	29—29·6	23·7
	12n.—2 p.m.	3·0—2·0	29·6—34	21·0
	2—3 p.m.	2·0—1·4	34—34	21·6
	3—4 p.m.	1·4—1·0	34—32	17·5
	4—5 p.m.	1·0—0·7	32—31	13·9
Respiration	5—7 p.m.	0·7—0·8	31—23	2·7

It was thought there might exist in the grass leaves a substance capable of absorbing carbon dioxide—the existence of such a substance has been postulated by Warburg. (Spoehr 1926 and Stiles 1925). It was believed that the nature of the reactions occurring in the plant might be of the type $CO_2 \longrightarrow CO_2$ absorbed by some specific compound $\longrightarrow$ sugar $\longrightarrow$ starch. Transferring the leaves from a natural atmosphere to one containing an artificially increased amount of carbon dioxide resulted in the absorption of a greater amount of carbon dioxide by the absorbing substance in the plant, and hence produced an apparent high rate of photosynthesis.

The results obtained in this early work were not repeated in later experiments.

There is, however, a minor point regarding variations in the rate of photosynthesis which can be accounted for by postulating the presence of an absorbing substance. In two experiments (Table III gives the results obtained from one of them) there is a sharp drop in the rate of assimilation corresponding with a decrease in the light intensity, and this is followed by a higher rate of photosynthesis over the following period for no apparent increase in light intensity.

TABLE III.

Rates of assimilation and respiration of *Eragrostis curvula*.

	Time.	Percentage of CO_2	Temp. in degrees C.	Real assimln. or respiration in mgms. per sq. dcm. leaf surface per hr.
Assimilation	11.15 a.m. to 12.15 p.m.	1·4—1·2	19—18·5	11·1
	12.15 to 2.15 p.m.	1·2—0·7	18·5—18·5	12·3
	2.15 to 3.15 p.m.	0·7—0·7	18·5—17	1·5
	3.15 to 4.15 p.m.	0·7—0·6	17—16·5	5·2
Respiration	4.15 to 5.15 p.m.	0·6—0·6	16·5—16·2	1·5

This might possibly be the result of the fall in light intensity affecting the equilibrium $CO_2 \longrightarrow$ absorbed by some specific substance $\longrightarrow$ sugar, very nearly sufficient carbon dioxide being held by the absorbing substance for the use of the plant under the decreased light intensity; hence little carbon dioxide is taken in by the plant. Eventually, however, the equilibrium is restored, carbon dioxide being absorbed at the same rate as it is being utilised by the plant, and hence an increased rate of assimilation over the following period is recorded.

A number of experiments were carried out to test whether an absorbing substance did in fact exist, by measuring the respiration rate after the leaves had been transferred from direct sunlight and normal carbon dioxide concentration to darkness and high carbon dioxide concentration (5%). The respiration rate increased slightly with time, whereas in earlier experiments where the carbon dioxide concentration was not increased on transferring the plant to darkness, the respiration rate usually decreased with time. This suggests that the leaves are capable of absorbing a slight amount of carbon dioxide in the dark. But the amount absorbed was not sufficient to account fully for the anomalous results obtained with darkened plants in the earlier experiments.

The ability of some plants to absorb carbon dioxide in the dark seems now to be established. Smith (Smith 1940) found that all the plants used in his experiments (including some members of the Gramineae) were able, with one possible exception, to absorb carbon dioxide in excess of that ascribable to the water they contained.

(d) *Variations in the respiration rate and their significance.*

In almost all the experiments in which the respiration rate was measured over a number of hours, it was found that the rate decreased with time, and that the decrease was usually greater than could be accounted for by changes in temperature. An experiment carried out to test whether an increase in glucose content resulted in a higher respiration rate yielded positive results—the rate was found to be approximately doubled on transferring leaves from water to a 3% glucose solution. The falling off in respiration rate found normally to occur with time, was probably due to the conversion of the products of photosynthesis into more complex and stable compounds.

(e) *General conclusions.*

As can be seen from Table IV, it would appear that for each particular species of grass, rate of assimilation and rate of respiration are to a certain extent correlated. The correlation becomes greater when rate of assimilation throughout the day, or total quantity of carbohydrate assimilated, is compared with the respiration rate. On the other hand, the fact that when allowances for the effect of temperature are made (assuming that Q10 is 2), the correlation is largely destroyed, suggests that the correlation was probably a purely fortuitous one of the following nature: a high rate of photosynthesis results from a high light intensity, with which is usually associated a high temperature, and this in turn results in a high respiration rate.

TABLE IV.

The maximum rates of assimilation obtained for the various experiments, and also the respiration rates.

Name of Plant.	Time.	Percentage of CO_2	Temperature in degrees Centigrade.	Real assimln. in mgms. per sq. dcm. leaf surface per hour.	Resp. in mgms per sq. dcm. leaf surf. per hr.
Panicum maximum	11 a.m.—12 noon	0·6—0·1	30·2—31·9	15·5	1·0
	2.15 —3.15 p.m.	0·9—0·5	30·8—39·6	10·9	1·5
	12 noon—2 p.m.	3·9—2·4	27 —36·9	18·6	0·6
	12.05—2.05 p.m.	1·9—0·4	37 —37	16·2	3·2
	12 noon—2 p.m.	4·8—3·5	24 —32·5	21·6	3·0
Tricholaena rosea	12.45—1.45 p.m.	1·2—1·0	19·4—19·5	7·7	1·7
	2—3 p.m.	10·2—9·2	41 —42	33·3	3·2
	2—3 p.m.	4·7—3·6	34 —38	35·8	4·7
Eragrostis curvula	2—3 p.m.	2·0—1·4	34 —34	21·6	2·7
	12.15—2.15 p.m.	1·2—0·7	18·5—18·5	12·3	1·5
	11 a.m.—12 noon	3·5—3·1	21 —22	23·4	2·5
Themeda triandra var. *trachyspathea*	2—3 p.m.	8·0—7·8	37 —38·5	7·2	1·1
	10.50—11.50 a.m.	2·2—1·6	22·5—33	21·9	3·0
	2.15—3.15 p.m.	6·4—6·0	31 —40	13·9	2·8
Themeda triandra var. *glauca*	11.15 a.m.—12 noon	5·2—4·9	26 —27	26·4	1·4
	11.30 a.m. 12.30 p.m.	3·6—3·0	24 —27	47·2	6·0
Aristida junciformis	2–3 p.m.	5·1—4·4	37 —40	29·0	2·2
Senecio bupleuroides	1.30—2.30 p.m.	1·5—0·5	36 —36·5	30·1	4·3
Hypoxis rooperi	12 noon — 2 p.m.	5·3—4·5	27 —27	18·7	2·6

The relationship between the rate of photosynthesis and temperature for each particular experiment has already been pointed out; it would also appear that for each particular species there is as a general rule a correlation between the highest rate of photosynthesis and the temperature recorded during that rate. This is however not well illustrated in Table IV since other factors tended to modify the relationship—for instance, it would appear that in some of the experiments with *Panicum maximum* the concentration of carbon dioxide was a limiting factor, while in the case of *Themeda triandra* var. *trachyspathea*, in both experiments performed on clear days, the concentration of carbon dioxide would seem to have been sufficiently high to exert a narcotic effect. As was pointed out before, it is likely that the real correlation lies not between rate of assimilation and temperature, but between the former and light intensity.

It would also appear that as a general rule the plant tended to reach its highest rate of assimilation at or around midday; this tendency is not as clearly shown in Table IV as it might be, owing to the intervention of several factors. In the first place, if the sky were overcast either for the whole day or for part of the time (the former event will be indicated in Table IV by the relatively low temperature recorded during the maximum assimilation), light intensity may have been lower at midday that at some other period. Secondly, the concentration of carbon dioxide might become limiting before midday. In the third place, in those experiments in which the sunlight did not reach the leaves till after noon (as was the case with later experiments in this work), it is but to be expected that the highest rate of assimilation would occur during a later period.

It is interesting to note that the highest rate of assimilation recorded was given by *Themeda triandra* var. *glauca:* the next highest rate was obtained for *Tricholaena rosea*, followed by *Senecio bupleuroides* and *Aristida junciformis*. It is, however, perhaps inadvisable to draw any conclusions from these facts with regard to the behaviour of the plants under natural conditions.

There would appear under experimental conditions to have been a seasonal variation in the assimilation rates of the grasses. An experiment with *Panicum maximum* performed nearer summer than the previous experiments with the purpose of discovering such a variation, gave a higher rate of photosynthesis. The maximum rate of photosynthesis recorded for the day would probably have been greater but for the fact that the sky became overcast during the period 2-3 p.m., when the highest rates for experiments performed at this time of the year were normally obtained. As a result a full contrast was probably not obtained; but, as it was, an increased rate of assimilation for the experiment performed later in the year was observed. This was most likely due to increased light intensity, though differences in the age of the leaves may possibly have played a part. The latter factor was probably responsible for the results obtained with *Eragrostis curvula*, where an experiment performed nearer summer showed a higher rate of photosynthesis although conditions were otherwise less favourable than in an earlier experiment performed during winter. The effect of the age of the leaves may well affect the rate of assimilation under natural conditions, but it is unlikely that changes in the intensity of illumination on clear days throughout the year would do so. In this connection it is interesting to note that during a spell of dull, wet weather during the period October-November, in which but a few bright days supervened, the growth of grasses was very rapid and luxuriant. Since grasses are not characterised by a marked capacity for storage of the products of photosynthesis, it would appear that their assimilation rates could not have been seriously impeded by the low light intensity. The explanation must almost certainly lie in the fact that since carbon dioxide is limiting under natural conditions, the light intensity of full sunlight is not necessary for the highest assimilation of which the grasses are capable.

ACKNOWLEDGMENTS.

I wish to express my indebtedness to Professor A. W. Bayer of Natal University College for his kind advice and criticism. This work was carried out in the Department of Botany, Natal University College.

SUMMARY.

1. An apparatus for the measurement of the assimilation and respiration rates of grasses is described.
2. The relative importance of the factors temperature and light intensity with regard to the results obtained, is discussed.

3. The possibility of the existence of a specific substance in the plant for the absorption of carbon dioxide is considered.

4. The experiments carried out on various grasses and two associated plants of the grass-veld are discussed in their general aspects.

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DROUGHT RESISTANCE IN YOUNG CEREAL PLANTS

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Read 30th June, 1941.

An attempt was made to test the drought resistance of young cereal plants, by means of germinating seeds under standard conditions, and drying them down. Although the results in this paper must be regarded as essentially of a preliminary nature, they seem to be of sufficient interest to warrant publication.

According to Maximov (1935 p. 397), seedlings, particularly those of cereals, can be dried without losing their vitality, but no definite data are given. He states, however, that "*even germinating seeds* (italics are mine) may endure dessication, *provided the embryos have not attained any considerable size* . . . ." The tables given in this paper certainly go beyond this statement. The only other record of work which resembles my own experiments is that contained in a paper by Bonnier (1892). Although our aims are directly comparable, Bonnier's methods and material were considerably different.

In my first experiment, Haage and Schmidt's Spring Rye was germinated and grown at 21 C., in a large glass sided box. At night the box was illuminated by three 100 watt lamps, which were also used during the day to prevent water condensing on the glass sides of the box. The lamps were used only when continuous illumination was one of the standard conditions. The plants were grown or the seeds were germinated for 1, 2, 4, 6, 8 and 12 days, and then each lot was divided into six sets of 100 each, and each of these subdivisions was dried for 1, 2, 4, 6, 8 or 12 days respectively.

The seeds were germinated on filter paper placed on wet sand, in half of a petri dish. When dried, the seeds were removed from the filter paper in one mass. When regrowing, plants of 4 days and upwards were re-planted direct on sand.

In the following experiment, the plants were grown in the dark.

H&S's Spring Rye	Days Soaking						Days Drying
	1	2	4	6	8	12	
Percentage	97	89	65	70	0	0	1
of	83	92	55	36	0	0	2
Recoveries	91	70	20	20	0	0	4
after	70	84	44	4	0	0	6
drying	85	74	27	3	0	0	8
down	73	68	12	0	0	0	12

The average increase in weight of each batch after the full germination time was taken. This was considered important, because several experiments showed a different degree of "hydration," and consequently differing reactions after drying down. The drying down method at this stage was not very efficient, hence the erratic results obtained in the above table; this would particularly affect batches with different amounts of water to lose. The plants were also weighed during drying down, but the figures are not of sufficient importance to be included.

No figures can adequately convey the slight, but significant differences observed. The re-growth figures cannot, for example, indicate the rather small, slow-growing plants that emerged from the re-dried seeds of the 1-day-growing 12-days-drying plants. Again, 1:1 had the coleoptile or first leaf strongly tinged with red, this was less marked in 1:2 and 1:4, and not seen at all in the others. Remarks of a similar nature would be made for all the other categories, the 2, 4 and 6-days-grown-plants.

In the next experiment, the plants were grown under conditions similar to those described above, but in continuous illumination. In this experiment, none of the 4-days-grown plants recovered.

	Days Soaking						Days Drying
	1	2	4	6	8	12	
Percentage	49	58	0	58	0	0	1
Recoveries	63	73	0	54	0	0	2
after	65	58	0	3	0	0	4
drying	45	50	0	0	0	0	6
down	50	21	0	0	0	0	8
	37	28	0	0	0	0	12

A second experiment on the same lines was carried out with the main object of determining the percentage water on the oven dry weight, after drying down.

	Days Soaking			Days Drying
	2	4	6	
Percentage Recoveries after drying down	49	65	66	1
	52	38	46	2
	67	17	19	4
	76	10	0	6
	80	0	0	8
	28	0	0	12

	Days Soaking			Days Drying
	2	4	6	
Percentage water left in air dried sample plants, on oven dry weight.	27·7	111·2	382·5	1
	9·9	87·0	203·3	2
	11·6	38·2	95·6	4
	15·4	48·2	76·6	6
	9·9	17·2	67·5	8
	12·2	—	—	12

It must be pointed out that these determinations represent the percentage of water in a whole batch, irrespective of the number that might ultimately recover, and that the figures therefore, hardly represent more than the drying gradient, which in this ordinary air drying method, was bound to be uncertain and irregular.

A number of other seeds was then tested:—

Garton's Spring Rye, 25 C., continuous light.

	Days Soaking			Days Drying
	2	4	6	
Percentage Recoveries after drying down	77	44	63	1
	85	38	7	2
	40	27	8	4
	47	32	0	6
	51	14	0	8
	45	18	7	12

Haage and Schmidt's Winter Rye.

	Days soaking			Days drying
	2	4	6	
	30	52	53	1
Percentage	51	54	48	2
Recoveries	44	46	0	4
after	36	25	0	6
drying	35	21	0	8
down	36	12	0	12

Barley.	Days soaking			Days drying
	2	4	6	
	17	52	23	1
Percentage	6	53	18	2
Recoveries	8	63	0	4
after	11	46	0	6
drying	6	29	0	8
down	8	1	0	12

Oats.	Days Soaking			Days drying
	2	4	6	
Percentage	5	13	15	1
Recovery	6	15	17	2
after	10	6	0	4
drying	5	6	0	6
down	4	4	12	8
	5	4	2	12

In the next experiment, the temperature was raised to 32 C. This temperature was maintained during the growing period, and also during drying down.

	Days soaking			Days drying
	2	4	8	
Percentage recovery in continuous illumination. Garton's Spring Rye	14	22	63	1
	9	24	34	2
	27	2	12	4
	22	0	5	6
	24	34	1	8
	8	4	3	12
Percentage recovery in continuous dark. Garton's Spring Rye	41	39	26	1
	16	22	32	2
	36	30	20	4
	27	26	5	6
	45	2	0	8
	24	0	0	12
Percentage recovery in Barley in continuous illumination.	2	11	6	1
	1	5	4	2
	8	2	1	4
	8	0	0	6
	3	0	0	8
	0	0	0	12
Percentage recovery in Barley in dark.	2	0	6	1
	5	0	4	2
	11	3	1	4
	7	0	0	6
	1	0	0	8
	0	0	0	12

After the plants had been grown the usual number of days, before drying down, the "embryos" were taken out, and the process then carried on as usual. The experiment was at 25 C., in continuous light.

	Days soaking			Days drying
	2	4	6	
Percentage Recoveries.	12	36	61	1
	9	20	40	2
	0	8	0	4
	0	0	0	6
	0	0	0	8
	0	0	0	12

The average weight of the embryos on excision was 6, 37 and 58 mgs. respectively.

Plants were grown for 2, 4 and 6 days at 25 C., in continuous light, and were then placed in dessicators over water, for the periods given below. They were then re-grown.

	Days soaking			Days drying
	2	4	6	
Percentage Recoveries.	43	40	31	1
	6	41	44	2
	38	40	71	4
	50	38	34	6
	38	41	41	8
	27	51	40	12
	38	58	29	14
	14	53	33	16
	49	49	0	18
	59	45	0	20

This slow drying gradient proved that the plants had considerable resistance and vitality after long periods.

In another experiment, for comparison with the preceding table, after 1 to 12 days in the dessicators over water,- the plants were *dried* in air at 21 C., 12 days for 2-days-grown plants, 10 days for 4-days-grown plants, and 8 for 6-days-grown plants.

	Days soaking			Days drying
	2	4	6	
Percentage Recoveries.	43	9	12	1
	28	21	8	2
	27	11	3	4
	33	10	5	6
	—	18	1	8
	25	6	0	12

A number of experiments was conducted in order to eliminate the erratic recovery percentages, by a drying method that was more sure, and more easily controlled. For instance, plants were placed over concentrated sulphuric acid in dessicators, or air was drawn over towers of acid, before entering a chain of dessicators. In neither case was the drying gradient sufficiently severe; in any case the relatively small drying chambers made proper aeration difficult. Finally, the experimental plants were placed in a large chamber, in which the plants could be dried in a current of air, which was heated to 28 C. This made drying very severe.

	Days soaking			Days drying
	2	4	6	
Percentage Recoveries.	25	36	29	1
	33	43	27	2
	25	41	11	4
	26	34	7	6
	26	16	0	8
	18	0	0	12

The plants were grown at 21 C., in continuous light. Before placing the plants in the drying box mentioned above, the plants were allowed to dry for 1 day at room temperature, for comparison with the preceding experiment.

	Days soaking			Days drying
	2	4	6	
Percentage Reçoveries.	50	43	14	2
	39	11	0	4
	51	9	0	6
	31	17	0	8
	31	0	0	12

Plants were grown for 2, 4 and 6 days, and then dried down for 1, 2, 4, 6, 8 or 12 days. A sub-division from each of these was then re-grown for 2, 4 or 6 days. These groups were further sub-divided, dried for periods of 1, 2, 4, 6, 8 or 12 days, and then re-grown. The experiment was carried out at 25 C., in continuous light. As the table contains 124 items, it cannot be reproduced here. A portion has been selected in order to demonstrate the nature of the experiment and the sort of result obtained.

2 (days growing) : 12 (days drying) : 2 (days growing) : 1 (days drying) i.e·

2 : 12 : 2 : 1 — 21 small.
2 : 12 : 2 : 2 — 16.
2 : 12 : 2 : 4 — 27, 1 had two leaves.
2 : 12 : 2 : 6 — 13.
2 : 12 : 2 : 8 — 34 small.
2 : 12 : 2 : 12 — 40.
2 : 12 : 4 : 1 — 25, 6 had 2 leaves.
2 : 12 : 4 : 2 — 11, 2 had 2 leaves.
2 : 12 : 4 : 4 — 2.
2 : 12 : 4 : 6 — 7, only 1 leaf.
2 : 12 : 4 : 8 — 7 small, 4 have 2 leaves.
2 : 12 : 4 : 12 — 0.
2 : 12 : 6 : 1 — 23 good, 18 with 2 leaves.
2 : 12 : 6 : 2 — 25 good, all 2 leaves.
2 : 12 : 6 : 4 — 19, 9 had 2 leaves.
2 : 12 : 6 : 6 — 7, 6 had 2 leaves.
2 : 12 : 6 : 8 — 0,
2 : 12 : 6 : 12 — 0.

Or

6 : 4 : 2 1 — 27 good.
6 : 4 : 2 2 — 9 poor.
6 : 4 : 2 4 — 5.
6 : 4 : 2 6 — 0.
6 : 4 : 2 8 — 0.
6 : 4 : 2 12 — 0.
6 : 4 : 4 1 — 15 fair.
6 : 4 : 4 2 — 29 good, several 3 leaves.
6 : 4 : 4 4 : — 13, several 3 leaves.
6 : 4 : 4 6 — 5.
6 : 4 : 4 8 — 0.
6 : 4 : 4 12 — 0.
6 : 4 : 6 1 — 30, several 3 leaves.
6 : 4 : 6 2 — 18.
6 : 4 : 6 4 — 13 fair.
6 : 4 : 6 6 — 7, 2 only 1 leaf.
6 : 4 : 6 8 — 4 small.
6 : 4 : 6 12 — 0.

In one set of experiments, leaves, coleoptiles and roots were cut at different lengths, before and after drying, and it was shown that better results were obtained when regrowing, if the cutting was done after drying. This of course, did not apply to cut roots.

A number of experiments was carried out on embryos, and an attempt was made to influence the drought resistance of the embryo while still in the seed. No positive results were obtained. A considerable amount of work was also done with excised embryos. It may be mentioned perhaps, that embryos of rye, extracted dry, were quite capable of growing on agar, provided this contained sugar. Sometimes, however, the plant behaved queerly, as if the leaf had lost some sort of geotropic tropism. Embryos excised dry did not grow on sugarless agar or gelatin. By using short soaking periods between 1 and 24 hours, some evidence was obtained of the possible transfer of a substance, quite likely of a hormone nature, which made a considerable difference to the growth of excised embryos on sugar agar.

In the course of these experiments, a number of attempts was made to sterilise seed and embryos with a large number of varied disinfectants, but none gave very good results. Finally, a rough technique, using chlorine gas was evolved which seemed to offer a partial solution.

While the results given in this paper seem curious and very interesting to the writer, it would hardly be possible to attempt a discussion of their full significance without much fuller data. It may be pointed out, however, among other things, that the temperatures at which all the experiments were carried out, were high, and that a 2 days' experimental plant would really be quite old. Further, the temperature chosen was quite arbitrary, and by no means guaranteed to give the best possible result. Again, the method of regrowing was not likely to give the best results statistically, while the method of drying in most of the experiments added to the irregularity in the result. No statistical analysis was made at any time of the recovery figures.

It may be suggested that 2, 4 and 6 day plants have very different physiological constitutions, and re-act in very different ways to most tests.

The drying process itself, seemed to have a definite formative effect—as might be expected, it had a dwarfing effect on plants grown to maturity, among other things.

It may be possible to improve drought resistance by pretreatment of seed. The writer could not feel justified in offering an opinion on that, at the moment.

This work was commenced and in part, carried out under the direction of Prof. Gregory, of the Royal College of Science, London. The writer would also like to thank Prof. Phillips, of the University of the Witwatersrand, for his interest and encouragement, and also, some helpful criticism.

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TETRAPLOIDY IN *CARICA PAPAYA L.* INDUCED BY COLCHICINE,

BY

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Read 30th June, 1941.

The potent alkaloid colchicine which is obtained from the autumn crocus, *Colchicum autumnale,* has been used effectively by investigators as a means to induce a doubling of the chromosomes in plants. In the following paper studies are reported of tetraploid plants of *Carica papaya* which were induced by the treatment of the terminal buds of seedlings. Marguerite E. Hartung (1939, 1940) observed abnormalities in the growth of papaya plants treated with colchicine but she failed to induce tetraploidy. However, one of the treated plants is described as a "dwarf polyploid" which was apparently sterile since " the flower buds produced dropped before reaching anthesis."

EXPERIMENTAL METHODS

Potted seedlings of about 6 inches in height were treated successfully with aqueous solutions of colchicine and similar solutions containing agar. One to two drops of the aqueous solutions of colchicine were applied to the terminal buds by means of a medicine dropper, 2-3 times a day for 1 to 4 days in succession. The agar solutions are allowed to set in small glass phials which may be easily fixed on the plant, without any additional support, and plugged with cotton wool to prevent any leakage of the agar solution. It is advisable to remove all the leaves in order to force the tip of the stem into the agar. Whereas the first is the most economical method, the latter provides a continual contact of the treated buds with a substance containing colchicine in solution. The effective concentrations of colchicine for both methods were found to range from 0·06% to 0·5%. However, it was found to be more effective to use concentrations ranging from 0·06% to 0·1% and increase the time of exposure to the drug, than to treat the plants for shorter periods at higher concentrations. In the case of the latter the development of the treated tissue may become so distorted that the plants either may be killed or remain stunted. The first noticeable effect of the drug is a temporary inhibition of the growth of the treated buds so that the buds lower down are encouraged to develop. Such shoots should be removed regularly until the terminal buds grow actively.

TETRAPLOIDY

Of the 64 treated plants 14 are apparently tetraploid and of these 9 are females, 4 are males and 1 an hermaphrodite. The other plants are mostly unaffected but a small number of them show various abnormalities such as dwarfism and sterility, which would suggest that some or other chromosome abnormality had been induced. Preliminary chromosome studies of some of these plants have revealed various abnormalities in meiosis, but this will be discussed at a later date.

In Plate 1 evidence is presented of the tetraploid nature of a staminate and of a pistillate plant. The two staminate plants illustrated in Fig. 8 are closely related and of the same age and are A, a tetraploid and B, a diploid. The greater vigour of the tetraploid is observed in both the height of the plant and in the size of the leaves. In the tetraploid the leaves are stiffer in texture than those of the diploid, this is shown by the spreading nature of the tetraploid leaves, and the downward inclination of the diploid leaves. At about 6 inches above ground level callous formation (see Fig. 9) is observed, this is the level at which the stem was treated when the plant was in the seedling stage. It is possible that the difference in vigour between tetraploids and diploids is even more pronounced than as is revealed in Fig. 8, since the formation of a callous and the diploid nature of the roots may be retarding factors.

In Fig. 1 camera lucida drawings are presented of the chromosomes in the microsporocytes of diploid and tetraploid plants, viz.: A. Metaphase I—normal diploid ($n=9$); B. Asynaptic metaphase I—tetraploid ($n=18$); C. Late anaphase I showing diploid nature of bivalent chromosomes separating. Fig. 2 is a micro-photograph of the chromosomes in the microsporocyte of the tetraploid ($n=18$).

Tetraploidy results in an increase in the size of the pollen grains (compare Figs. 4 ($n=18$) and 5 ($n=9$)), and is also characterised by the presence of about 25% of sterile pollen (see Fig. 4). A difference in the size of the flowers is also clearly seen in Fig. 6 where A represents the flowers of a tetraploid and B of a diploid staminate plant.

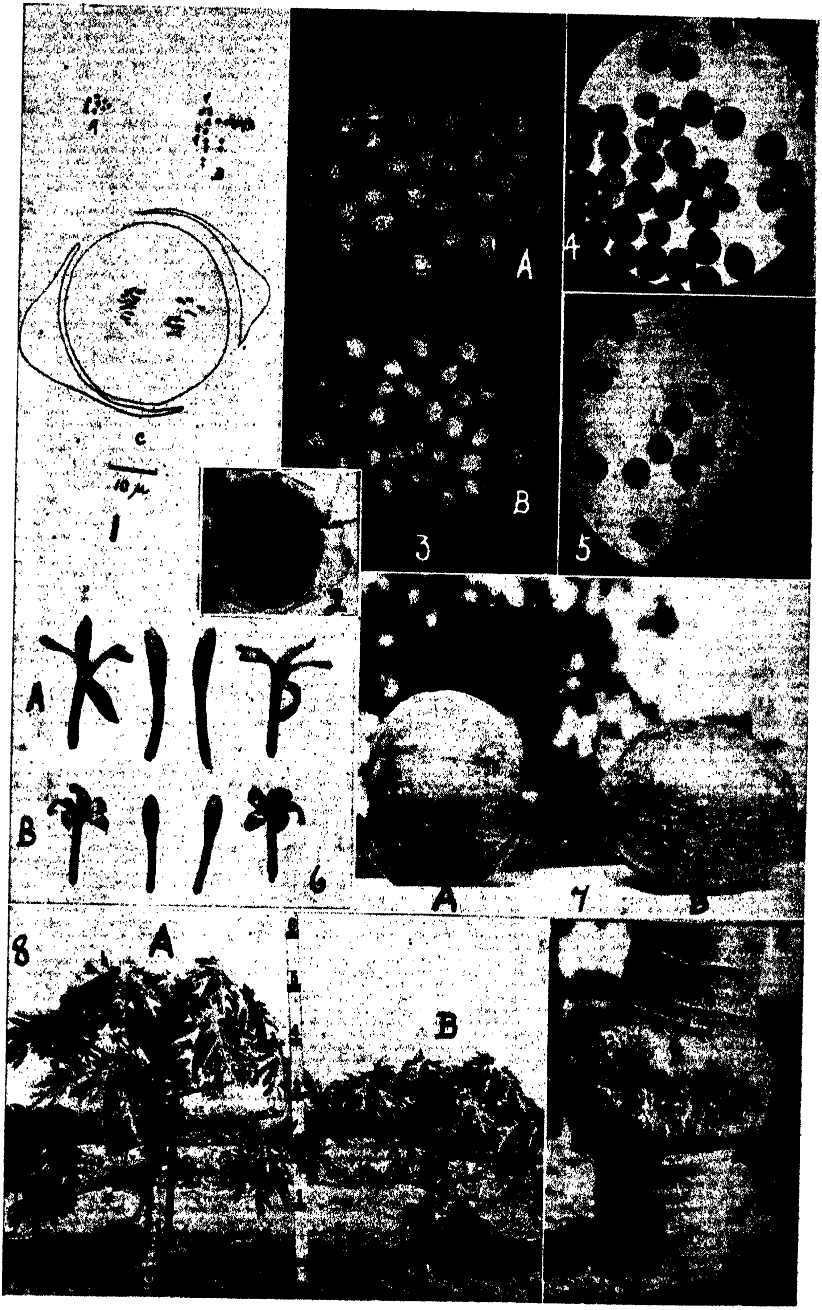

Plate I.

As yet no chromosome studies are available of the female tetraploid but the tetraploid nature of the plant is suggested strongly by the evidence presented below.

In a comparative study of the effect of diploidy and tetraploidy on the shape of the fruits of the *Cucurbitaceae* it was found (Blakeslee, 1941) that the diploid pear-shaped squash is longer than wide, whereas the fruit of the tetraploid is disc-shaped. This same tendency is observed in a comparative study of the papaya fruits illustrated in Figs. 7A (tetraploid) and 7B (diploid), e.g. the ratio of the length to the width of diploid fruits is, as a rule, in excess of 1, whereas in the tetraploid the ratio is less than 1. The fruits illustrated in Fig. 7 were taken from sister plants and in Fig. 3 a comparative study is made of the seed obtained from these fruits. The seed shown in Fig. 3A is from the tetraploid fruit but is apparently triploid in nature since the flower from which this fruit developed was pollinated with diploid pollen. However, there is little doubt about the increase in size of the triploid seed (Fig. 3A) when compared with the diploid seed (Fig. 3B). Tetraploid crosses have been made but the fruit is still too immature for seed-size studies. The fertility of the tetraploid is reduced very little, if at all, since seed counts are in the neighbourhood of 1200 per fruit, which number is regarded as normal for the diploid fruit. Although the seed of the tetraploid is normal in appearance this observation must still be verified by germination studies.

DISCUSSION

Dobzhansky (1937) observes that the available data suggest that polyploidy is not likely to occur in dioecious plants, since sex determination may be upset easily by the addition of extra sets of chromosomes resulting in the production of usually abnormal or sterile forms. This is disproved (Blakeslee, 1941) by experiments with *Melandrium* in which " a doubling of chromosome numbers ultimately leads to a balanced tetraploid population with approximately equal numbers of male (XXXY) and female XXXX) individuals." Additional support is given to this view by the observation on the male and female papaya tetraploids. According to the hypothesis of sex determination in *Carica papaya* developed by Hofmeyr (1938), M_1 determines maleness and m femaleness, hence the genotype of the male is M_1m and of the female m m. Hence the male and female tetraploids reported in this paper should be respectively of the genotypes M_1M_1m m and m m m m. Pollen studies as well as evidence derived from the crossing of the male tetraploid with female diploids and tetraploids, indicate that the tetraploid pollen functions normally in fertilisation. The examination of the fruits of female tetraploids leads to similar conclusions concerning the fertility of such tetraploids. Preliminary observations serve to indicate that the male tetraploid is *more male-like* in its characteristics than the male diploid. This is apparently borne out by the observation that up to the present no sex reversal has occurred in any of the flowers of the 4 male tetraploids studied, whereas it is of common occurrence in the flowers of male diploids and has been observed in siblings of the same age grown under similar environmental conditions.

SUMMARY

(1) Tetraploidy was induced by the treatment of seedlings of *Carica papaya* with colchicine.

(2) The tetraploid nature of these plants was verified by chromosome studies e.g. diploid ($n=9$), tetraploid ($n=18$).

(3) An increase in the size of the pollen grains. flowers, seed and leaves and an increase in general vigour were observed in tetraploid plants.

(4) The ratio of the length to the width of tetraploid fruits is less than 1, whereas it exceeds 1 in diploids.

(5) Tetraploids are apparently highly fertile.

(6) The male-like qualities are apparently accentuated in the staminate tree as the result of tetraploidy.

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A COMPARISON OF QUADRAT RESULTS AND PHENOLOGICAL DATA IN A SERIES OF HIGHVELD GRASSLAND GRAZING EXPERIMENTS SUBJECTED TO DIFFERENT TREATMENTS OVER A PERIOD OF SIX YEARS

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Introduction.

The experimental work on which this paper is based was carried out on Frankenwald, the Botanical Research Station of the University of the Witwatersrand, some twelve miles north of Johannesburg. The soil originating from the underlying Old Granite which covers this area is of an acid nature. The experimental plots were laid out in 1933 by Messrs. African Explosives and Industries Limited and the University of the Witwatersrand. The objects were to test the merits of certain fertilizers and to study the reaction of the vegetation in the differently treated plots.

In each camp ten quadrats 1 square metre each were laid out and analysed in 1933. These were again analysed in 1936 and 1940. The methods of analyses, the history and geology of the experimental area were described by Glover (1936). The estimation of the percentage basal cover in 1940 was done in the same way as in 1933 and 1936. Ten quadrats were not found on re-listing in 1940, and must be considered lost. In working out the average percentage cover for the different plots, the readings of the lost quadrats were omitted from tables given in 1933 and 1936 in order to make the figures comparable.

In most instances generalisations could not be made and no conclusions could be drawn, but results clearly indicate that the change in certain species is most consistent, according to the treatments given. It is, for example, clearly shown that in most cases the small *tufted* and *runner* grasses cannot compete for light with the tall *bunch* grasses, and that under conditions of protection these species are smothered and suffer severely, while the larger *bunch* grasses develop to their maximum capacity.

All the grass on plots 1-10 was burned off in July, 1939, to get rid of the coarse dry material left behind by the grazing animals and the mower. The camps had been fertilized, mown and grazed during the growing seasons.

The grazing, veld management and beef production is described by Messrs. Hall, Meredith and Murray. This Journal, XXXVII, 111-129 (1940).

Fertilizer Treatments for the various plots.

The camps are each two morgen (4.2 acres) in extent and the amounts are given in lbs per morgen.

Original Scheme: Plots 1—P; 2—PN; 3—PNK; 4—PN2K; 5—PN3K; 6—O; 7—Ca; 8—PCa; 9—PNCa; 10—PNKCa; 11—OO.

Key: O—No fertilizer; P—400 lbs. of equal quantities of super—and rock phosphate; N—200 lbs. of sulphate of ammonia; K—80 lbs. of muriate of potash; Ca—2000 lbs. of carbonate of lime; OO—No fertilizer and no grazing.

" The fertilizers are applied annually in spring, except for the Ca which is applied every fifth year and the extra N dressings which are applied at convenient intervals during the growing season." (This Journal, 1937.) Amended Scheme: " From the 1937-38 season onwards, the PN2K treatment was changed to PN3K and the PN3K treatment to PN3KCa. This allowed five treatments to be compared: viz., O, P, PN, PNK and PN3K and by subdividing the two-morgen camps, it was possible to obtain four one-morgen camps of each treatment, of which two of each treatment were also limed." (Hall, Meredith & Murray, 1940.)

DISCUSSION OF THE QUADRAT RESULTS.

PLOT A1. (*Treatment: Phosphorus, P.*)

The growth in this plot is poor but the cover is good, even and homogeneous. All the grasses are well-grazed except *Elyonurus* which has gone to flower. The *average percentage total* shows a decrease from 16.98% *in* 1936 to

14.83% *in* 1940; in 1933 *it was* 22.85%, here the decrease is marked and progressive. Although in the case of the control quadrat, there is no significant change in the *total percentage* since 1936, certain species show either a marked increase or decrease. The increase of *Trachypogon plumosus* and *Tristachya hispida* and the decrease of *Brachiaria serrata* and *Eragrostis chalcantha* in the control quadrat are marked.

PLOT A2. (Phosphorus and Nitrogen, PN.)

The quadrat figures show a marked decrease in the total average in the plot since 1936. In the control quadrat, an increase of nearly 4% is shown since 1936. This is largely due to an increase in *Trachypogon plumosus* and *Tristachya hispida*. The general appearance of the camp is good; the cover is homogeneous. *Elyonurus argenteus* was left ungrazed and is flowering but all the other grasses such as *Harpechloa falx, Tristachya hispida, Trachypogon plumosus, Eragrostis* and others are evenly grazed.

PLOT A3. (Phosphorus, Nitrogen and Potash, PNK.)

The grasses in this plot are more rank and less evenly grazed than in Nos. 1 and 2. As in the rest of the plots *Elyonurus argenteus* was not grazed and is in flower. *Trachypogon plumosus, Tristachya hispida, Harpechloa falx* and the various species of *Eragrostis* are well grazed. The leaves of many *Senecio coronatus* plants were eaten by the cattle. There is no significant change in the average cover since 1936, though the control quadrat shows a decrease from 13.13% *in* 1936 to 10.05% *in* 1940; in 1933 the value was 37.49%. Pioneer grasses such as various species of *Eragrostis* and *Hyparrhenia* hirta have increased considerably in the plot since 1936.

PLOT A4. (Phosphorus, Nitrogen (twice) and Potash, PN2K.)

Signs of degeneration of the original veld has become much more evident since 1936 and is also reflected in the quadrat results. *Hyparrhenia hirta, Eragrostis gummiflua* and other species of *Eragrostis* have become locally very frequent; *Cynodon dactylon* is conspicuously spreading in small bare areas to most parts of the plot. *Solanum capense* is locally frequent. The growth in the plot is very vigorous and consequently not as even as in Nos. 1 and 2. *Hyparrhenia hirta*, the various species of *Eragrostis* and *Harpechloa falx* are well grazed, provided that they are kept in a young and palatable stage. If this veld is to be utilised to its full extent, it will be necessary to make frequent use of the mower and fairly heavy early grazing may also be necessary. In the control there is no appreciable change since 1936 but the average percentage cover for the plot shows an increase. This, however, is largely due to the increase of *Eragrostis spp.*, *Hyparrhenia hirta*, *Digitaria tricholaenoides* and *Cynodon dactylon*.

PLOT A5. (Phosphorus, Nitrogen (three dressings) and Potash, PN3K.)

Bare patches in this plot have become less conspicuous since 1936 largely due to the re-colonisation of such areas by *Cynodon dactylon*, *Eragrostis spp.* and *Hyparrhenia hirta*. Weeds, however, have become more abundant during the previous two seasons, there was a flush of *Gnaphalium undulatum*, *Erigeron canadense* and *Conyza ambigua* while various other annuals were present; e.g., *Tagetes minuta*, *Walafrida densiflora*, *Chloris virgata*, *Eleusine indica*, *Lepidium linoides*, *Senecio laevigatus*, *Digitaria horizontalis*, *Nidorella anomala* and others. Though in small amounts only, these were actually present in the quadrats. The growth is very vigorous and the grass is dark green. A considerable increase in cover is shown since 1936, though the control quadrat shows a slight depression. It is noticeable in all the plots except Nos. 3, 4 and 5, that a considerable decrease in average percentage cover has taken place since 1936. It is in these three plots where the greatest increase of *Cynodon dactylon*, *Eragrostis spp.* and *Hyparrhenia hirta* occurs. As in plot 4 it will be desirable to mow this type of veld at frequent intervals and early grazing should be employed for the best utilisation.

PLOT A6. (No fertilizer, O.)

Growth in A6 is very poor as compared with A5, but it is even, homogeneous and evenly grazed and there are no weeds. The veld is not as green as in A5. The cover is good, but has actually decreased further since 1936 in the plot as well as in the control quadrat.

PLOT A7. (Lime, Ca.)

This plot has an appearance similar to A6 and is also very homogeneous and even but poor. In 1936 there was an increase in the average percentage total and in the control but in 1940 there was a marked decrease in both cases. There is a very close resemblance in percentage cover between A6 and A7 both in the plot and control.

PLOT A8. (Phosphorus and Lime, PCa.)

The cover in A8 is good and even but the quadrat results show a considerable decrease in the plot since 1936. There is also a further decrease in the control quadrat.

PLOT A9. (Phosphorus, Nitrogen and Lime: PNCa.)

The cover appears to be much thicker and the grass much greener than in A6—A8, but the quadrat results show a marked decrease since 1936. The decrease of *Digitaria tricholaenoides* largely accounts for the depression reflected in the total percentage cover. (Decreased from 9.93% in 1936 to 3.59% in 1940; in 1933 the value was 5.53%.) The cause of this decrease in *Digitaria tricholaenoides* may be the burning in July, 1939, as this species is usually badly damaged by fire owing to its prostrate growth form. As would be expected, this is more noticeable in Nos. 9 and 10, where the cover was thick and resulted in a fierce fire. In A6 for example, there is only a slight decrease. In A3 and 4 however, an increase is shown. Weeds such as *Gnaphalium undulatum* and *Conyza ambigua* are present in small quantities, but are not conspicuous. *Cynodon dactylon* and *Eragrostis spp.* have slightly increased. The control quadrat shows a further decrease since 1936.

PLOT A10. (Phosphorus, Nitrogen, Potash and Lime: PNKCa.)

From observations, this plot appears to be better than any of the previous ones. The cover is good, the growth vigorous and green. Although there are some weeds (*Gnaphalium undulatum, Conyza ambigua,* etc.) and *Cynodon* present, there are no signs of deterioration. In spite of this the quadrat results show a considerable decrease in the total percentage cover. This, however, as in A9, is largely due to the decrease in *Digitaria tricholaenoides* which was probably the result of the burning in July 1939. The control quadrat shows a slight increase since 1936.

PLOT A11. (Control: OO). No fertilizer and no Grazing.

There is a large accumulation of dry material in this plot; but it appears quite green in summer and *Tristachya* *hispida* flowers profusely early in the season. On inspection the plot looks very rank, but the quadrat results show a further decrease in the percentage total cover.

GENERAL DISCUSSION.

As personal error and various other factors have to be taken into consideration, it is not desirable to draw definite conclusions from the quadrat results even after 6 years treatment. The change in certain species, however, seem to be so consistent and appreciable over the 6 years period that a number of suggestions might well be attempted. It will be found that if the quadrat results are considered in conjunction with the phenological observations, a large amount of valuable information may be obtained. Some changes are more clearly seen from the quadrat results while others are more easily detected from general observations.

The more important species of grass may be classed into several different groups according to their behaviour when treated in different ways:

(1) *Grasses that decrease in both grazed and protected veld.*

Brachiaria serrata and *Eragrostis chalcantha* show a marked decrease in all the plots and the controls. Both these species are small bunch grasses and cannot compete against the rank growing plants of *Trachypogon plumosus*, *Tristachya hispida* and others. Consequently they get smothered in protected veld. As they are very small and perhaps more palatable than some of the taller grasses, it is possible that they are being grazed down consistently and get damaged to a certain extent. It is, however, not what would be expected in the case of *Eragrostis chalcantha*.

(2) *Grasses tending to decrease in grazed and increase in protected veld.*

Elyonurus argenteus, *Trachypogon plumosus* and *Tristachya hispida* appear to fall into this group. They are all large bunch grasses that grow very rank under protected conditions, and seem to form an advanced stage in grassland succession on the Highveld. These species shoot very early in the season and usually have to stand up to heavy grazing in early spring while they are still palatable. This may contribute towards an explanation for their decrease in grazed plots.

(3) *Grasses that increase in grazed and decrease in protected veld.*

Although the contrary is shown in these quadrat results, there usually seems to be a marked increase in *Digitaria tricholaenoides* in grazed plots provided the grazing pressure is not very severe. Nearly all the plots show a marked decrease since 1936, whereas in 1936 the results showed a considerable increase for the three years previous to that date. As has already been mentioned, this decrease shown in 1940 may be due to the burning of the plots in July, 1939. In all the control quadrats there is a considerable decrease in *Digitaria tricholaenoides* since 1933.

The reason for this peculiar behaviour of *D. tricholaenoides* in protected, grazed and burned veld seems to be its prostrate form. In protected veld, it cannot compete with the tall grasses for light, and therefore gets smothered as the result. Burning seems to damage the runners and so kill off some of the plants, and its growth is encouraged by grazing treatments when lateral spreading takes place. This behaviour of *D. tricholaenoides* under different treatments has also been brought out clearly in another series of experiments at Frankenwald (Isolation Transect).

(4) *Grasses that decrease in protected veld.*

Themeda triandra and *Heteropogon contortus* consistently decrease in protected veld on account of their being smothered by taller grasses. In grazed veld they do not seem to undergo any significant change provided that the treatment is not of a very severe nature. In the Isolation Transect at Frankenwald, *Heteropogon contortus* and *Themeda Triandra* showed a marked decrease in burned, grazed and control plots over a period of six years. *Themeda triandra* was found to thrive in burned plots and to die out in protected plots at Crescent Creek, in experimental plots at Drylands, near Standerton and in the Bethal district.

(5) *Secondary grasses and indicators of degeneration of the original veld type.*

It should be noticed that plots 3, 4 and 5 are the only ones where no decrease in the average percentage cover is shown. From the quadrat figures it could be clearly seen that the increase in *Hyparrhenia hirta, Cynodon dactylon* and various species of *Eragrostis* compensates for the slight increase in the percentage cover of these plots. Growth in these plots is very vigorous.

It is in No. 5 where the highest number of cattle days and the biggest increase in beef production was shown, but it is also in this camp where the greatest amount of deterioration of the original veld is evident. Since 1933, and more especially since 1936, there is a marked increase in *Hyparrhenia hirta*, *Eragrostis spp.*, *Cynodon dactylon* and various annual grasses and weeds such as *Eleusine indica*, *Chloris virgata*, *Digitaria horizontalis*, *Gnaphalium undulatum*, *Erigeron canadense*, *Nidorella anomala*, *Tagetes minuta*, *Senecio laevigatus*, *Walafrida densiflora*, *Lepidium liniodes*, *Conyza ambigua* and various other species. It is interesting to note that in plots No. 1 and 6, although the cover and growth seems much poorer, there is no sign of any weeds coming in and little change in the veld can be noticed. *Harpecloa falx* has undergone little change except in A5, where an increase is shown. This coincides with field observations.

It is of importance to note that the various species of *Eragrostis* are well grazed by stock early in the season while these grasses are still young and palatable. Early spring grazing and mowing treatments will therefore prove necessary if this veld type is to be fully utilised. It is however not possible to say what further effects such treatments will have on the veld. It is possible that it might result in a further increase of *Cynodon dactylon*.

Zizyphus zeyheriana, sedges, Monocotyledons and Dicotyledons—other than annual weeds—appear to have remained more or less unchanged during the six years. This is contrary to what was originally expected in the case of *Zizyphus zeyheriana*, which occurs abundantly and was thought to be spreading around termitaria.

It is difficult to draw any conclusions on the behaviour of the following species, as they are present in small amounts and do not show any significant changes: *Andropogon amplectens*, *Rhynchelytrum setifolium*, *Sporobolus fimbriatus*, *Aristida Welwitschii*, *Andropogon appendiculatus*, *Monocymbium ceresiiforme*, *Panicum natalense* and *Urelytrum squarrosum*. It appears, however, that the latter two species increase in veld that is protected from grazing over a long period. *Microchloa caffra* appears to decrease in protected veld but does not seem to undergo any considerable change in moderately grazed veld.

CONCLUSIONS.

(1) The quadrat results should be considered in conjunction with phenological observations as the number of quadrats per plot is not enough to give results representative of the whole area.

(2) The quadrats, though inadequate in number, reflect some interesting results after six years treatment, and indicate significant changes in some of the plots. On the whole the results seem fairly consistent.

(3) *Brachiaria serrata* and *Eragrostis chalcantha* appear to decrease in grazed as well as in protected veld, being damaged in the former and smothered by rank grasses in the latter case.

(4) *Elyonurus argenteus, Trachypogon plumosus* and *Tristachya hispida* appear to decrease in grazed and increase in protected veld. They belong to the large bunch grasses and grow very rank in ungrazed veld.

(5) *Digitaria tricholaenoides* appears to increase in grazed and decrease in protected veld. Burning is detrimental to this species as the runners are damaged by fire. In rank ungrazed veld, decreased light intensity causes its deterioration.

(6) *Themeda triandra* and *Heteropogon contortus* show a consistent decrease in veld under protected conditions.

(7) In the fertilized plots receiving extra dressings of nitrogen (A3, 4 and 5), the increase in growth and vigour is very striking but there are also signs of degeneration and a marked increase of secondary grasses such as *Eragrostis spp., Cynodon dactylon, Hyparrhenia hirta* and various weeds.

(8) A slight decrease in total cover is shown in A1 and A6, but there are no signs of degeneration and the growth is very even.

(9) The control quadrats in most cases show a decrease in total cover but an increase is shown for *Trachypogon plumosus* and *Tristachya hispida.*

TABLE 1.

	Average Percentage Total for plots A1—10.			Percentage for the Control quadrats and A11.		
	1940	1936	1933	1940	1936	1933
Plot A1 ...	14·83	16·98	22·85	13·81	12·18	24·06
2 ...	17·21	27·17	23·69	16·61	12·66	33·06
3 ...	16·48	15·65	19·26	10·05	13·13	37·49
4 ...	19·26	10·78	13·34	12·50	12·26	19·26
5 ...	20·26	16·18	19·78	10·85	11·91	24·61
6 ...	13·72	16·54	19·20	12·46	14·98	20·27
7 ...	12·85	20·79	16·91	13·99	21·91	16·52
8 ...	13·75	20·65	14·70	11·00	13·90	15·80
9 ...	15·22	26·15	20·34	11·40	16·35	17·04
10 ...	14·46	24·04	15·18	13·12	11·79	17·60
11 ...	—	—	—	12·40	14·12	14·63
(Average)						

TABLE 2.

Digitaria tricholaenoides: The following figures show a marked and consistent decrease in *Digitaria tricholaenoides* in all except two plots.

	Average Percentage in plot.			Percentage in Control.		
	1940	1936	1933	1940	1936	1933
Plot A1 ...	3·07	3·61	5·16	—	—	—
2 ...	4·65	5·51	5·13	0·14	0·52	2·61
3 ...	2·11	1·32	1·21	0·13	1·70	2·90
4 ...	3·15	—	—	0·65	1·44	3·24
5 ...	0·89	1·00	0·76	0·80	3·03	7·78
6 ...	0·41	0·74	0·20	0·55	0·66	0·69
7 ...	0·51	3·02	1·36	1·77	5·81	3·26
8 ...	1·09	2·17	0·56	0·58	1·48	1·00
9 ...	3·59	9·93	5·53	2·39	7·22	8·09
10 ...	1·15	6·45	0·87	0·02	0·42	3·57
11 ...	—	—	—	0·28	0·66	0·83
Total Average	2·06	3·38	2·08	0·66	2·09	3·09

TABLE 3.

	Total average percentages in plots A1—10.			Total average percentages in Control corners and A11.		
	1940	1936	1933	1940	1936	1933
Brachiaria serrata	0·31	0·63	0·71	0·40	0·89	0·87
Elyonurus argenteus	0·80	1·49	2·37	0·89	0·89	1·46
Eragrostis chalcantha ...	1·33	2·23	2·40	0·20	0·57	2·63
Heteropogon contortus ...	1·76	2·04	2·51	0·13	0·76	1·72
Themeda triandra	0·26	0·33	0·26	0·01	0·15	0·33
Trachypogon plumosus ...	1·56	1·28	1·54	3·47	2·86	4·05
Tristachya hispida	1·50	1·56	1·45	4·23	2·69	2·96
Tristachya Rehmannii ...	0·24	0·70	1·13	0·14	0·38	0·50

It is evident from the following table that if the increase of *Cynodon dactylon, Eragrostis spp.* and *Hyparrhenia hirta* were to be omitted from the totals, an appreciable decrease would have been shown in the percentage total cover of plots 3, 4 and 5.

TABLE 4.

	Plot.			Control.		
	1940	1936	1933	1940	1936	1933
***A*.3**						
Cynodon dactylon ...	0·07	0·27	0·08	—	—	—
Eragrostis spp.	0·78	0·01	0·07	—	—	—
Hyparrhenia hirta ...	0·10	—	—	—	—	0·12
Total for 3 species ...	0·95	0·28	0·15	—	—	0·12
Total average for plot ...	16·46	16·26	19·03	10·43	13·13	24·62
***A*.4.**						
Cynodon dactylon ...	1·62	—	—	—	—	—
Eragrostis spp.	4·98	—	—	—	0·10	0·02
Hyparrhenia hirta ...	1·00	—	—	—	—	—
Total for 3 species ...	7·60	—	—	—	0·10	0·02
Total average for plot ...	18·62	16·63	19·81	12·50	12·26	17·10
***A*.5.**						
Cynodon dactylon ...	4·61	0·01	—	—	—	—
Eragrostis spp.	2·56	0·06	0·76	—	—	—
Hyparrhenia hirta ...	0·05	—	—	—	—	—
Total for 3 species ...	7·22	0·07	0·76	—	—	—
Total average for plot ...	16·61	16·97	20·11	10·85	11·91	24·71
***A*.6.**						
Cynodon dactylon ...	0·01	0·01	—	—	—	—
Eragrostis spp.	0·12	0·02	0·14	—	—	—
Hyparrhenia hirta ...	0·02	—	—	—	—	—
Total for 3 species ...	0·15	0·03	0·14	—	—	0·41
Total average for plot ...	13·72	16·92	19·45	12·37	14·98	20·76

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possible through having accumulated some data at the inception of the experiments and since. I wish to thank Mr. E. B. Dickinson who helped me to re-list the quadrats during the early months of 1940.

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THE GROWTH OF PHYSICAL EFFICIENCY

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In the course of group surveys of nutrition and physical efficiency of various groups of the South African population, the necessity of obtaining exact evidence of normal standards of physical efficiency has been urgently felt. In spite of the obvious importance of possessing quantitative information on the working efficiency of the South African population, virtually no relevant figures had, until recently, been available in the educational and medical literature.

Physical efficiency is a complex phenomenon composed of the three factors, skill, endurance and strength. In order to obtain exact evidence on the normal rate of growth of physical efficiency in the South African population, three tests were devised which have been applied to thousands of South African school children. The tests included running over 100 yards which allows an insight into the co-ordinative abilities of the individuals, i.e., skill; putting the shot which measures strength; and running over 600 yards which demonstrates the individual's endurance.

At last year's Annual Meeting of the South African Association for the Advancement of Science, we gave an outline of the procedures followed in our study. *More than 22,000 measurements have been taken with European, Bantu, Indian, Coloured and Chinese children from between 5 to 20 years of age. To-day we are in a position to present, on the basis of our experimental material, the six standard tables of growth of physical efficiency at which we have aimed.*

As can be seen from the attached tables, we have first calculated the means of each physical efficiency component

for every age group between 5 and 20 years of age. In view of the large number of measurements available, the significance of each mean is very great. The curve of growth obtained by following the means is therefore a reliable indicator of a hitherto little understood developmental process of great practical significance.

Secondly, we have indicated the range of performance fluctuations in each age group. This range is, of course, of great importance. It enables future investigators to assess selected group standards in comparison with the normal curve.

Thirdly, we have analysed the percentage rate of progression by plotting each point on logarithmic paper. This procedure has revealed a number of observations of physiological interest to which we have already drawn attention in our last year's paper: namely, the difference in direction and rate of growth between boys and girls; the profound effects of puberty on the development of efficiency; and the distinct independence between skill, endurance and strength which were measured separately in our study.

The elaboration of statistically reliable physical efficiency standards for each age group of the school-going population in South Africa marks an important step towards our final goal: that of fully utilising South Africa's man power in order to achieve maximal national production.

At the next Annual Meeting of our Association, we hope to be able to present evidence as to comparative standards of physical efficiency of the principal racial and economic groups in South Africa. Furthermore, we are attempting to obtain further information on the educability of physical efficiency; ultimately we shall try to assess the economic value of the permanent mobilisation of South Africa's man power. That is our final aim.

NUMBER OF CHILDREN TESTED.

Total Number of tests, 21,999.

	Boys.	*Girls.*
Europeans:	1,806	1,261
Indian:	713	520
Coloured:	1,022	908
Bantu:	313	445
Chinese:	178	167
	4,032	3,301

DISCUSSION OF STATISTICAL RESULTS: MEANS.

100 Yards. There is a continuous significant improvement of performances from each age group to the next higher one. At puberty the rate of performance progress is slower than before and afterwards.

600 Yards. There is a continuous significant improvement of performances from each age group to the next higher one. At puberty the rate of performance progress is slower than before and afterwards.

Shot Put. There is a continuous significant improvement of performances from each age group to the next higher one. No puberty delay of rate of progress is reflected in the progression curve.

VARIABILITY.

Measured through co-efficient evaluation (V).

100 Yards. V decreases significantly from 11·92 ± ·29, in the 6-7 years age group, to 8·20 ± ·29 in the age group 17 years and older. This indicates that the variability in performance decreases with age progress.

600 Yards. V remains fairly constant around 10%. There is no evidence as to an influence of age on performance variability.

Shot Put. V decreases with increasing age. In the 6-7 years age group, V is 25.49% while in the age group 17 years and older it amounts to 18.49%.

Comparison of Variability. (a) The largest variability exists in the case of shot put.

(b) Variability in 100 yards performances is slightly larger than that in the 600 yards running times. With increasing age V decreases significantly with regard to both running performances, the 100 yards sprint and the 600 yards race.

A. PERCENTAGE INCREASE OF STRENGTH, SKILL AND ENDURANCE OF BOYS AND GIRLS DURING GROWTH.

1. *Boys*: (a) *Strength* develops at a much faster rate than skill or endurance. The rate of increases is constant up to the age of 15, and no retarding influence of puberty is noticeable with regard to this function.

(b) *Skill* increases at a rate slightly faster than endurance but considerably slower than strength.

The puberty stage is reflected by a slowing down of the rate of increase.

(c) *Endurance* increases with age at the slowest rate. The delaying developmental influence of puberty is clearly expressed in the figures.

2. *Girls*: (a) *Strength* develops at a much higher rate than skill or endurance. The rate of increases is constant up to the age of 13. After that, i.e. at puberty, the rate of increase is slowed down.

(b) *Skill* increases at a rate higher than that of endurance, but much slower than that of strength. The developmental increase is fairly constant up to the age of 13, whereafter it remains on a level.

(c) *Endurance* increases at a relatively slow rate up to the age of 13; it declines steadily after puberty.

B. COMPARING BOYS AND GIRLS.

1. *Strength*: The strength of boys is superior to that of girls. While in both cases it increases at about the same rate up to the age of 13, it afterwards increases at a faster rate in boys than in girls. An influence of puberty on strength is clearly reflected only in the case of girls.
2. *Skill*: Boys are again superior to girls. In both sexes retarding influence of puberty is reflected, although more so in the case of girls. In boys the rate of increase in skill is slightly lowered after puberty. In the case of girls, there is no spontaneous growth of skill after puberty at all.
3. *Endurance*: Boys are very much superior to girls. In both sexes the puberty stage is reflected in form of a retarding influence; but while in boys this influence is a temporary one, causing merely a slowing down of the rate of increase, there is a marked decline in endurance in the case of girls.

ACKNOWLEDGMENT.

The authors wish to acknowledge with thanks the support given to their investigations by the Union Secretary for Public Health.

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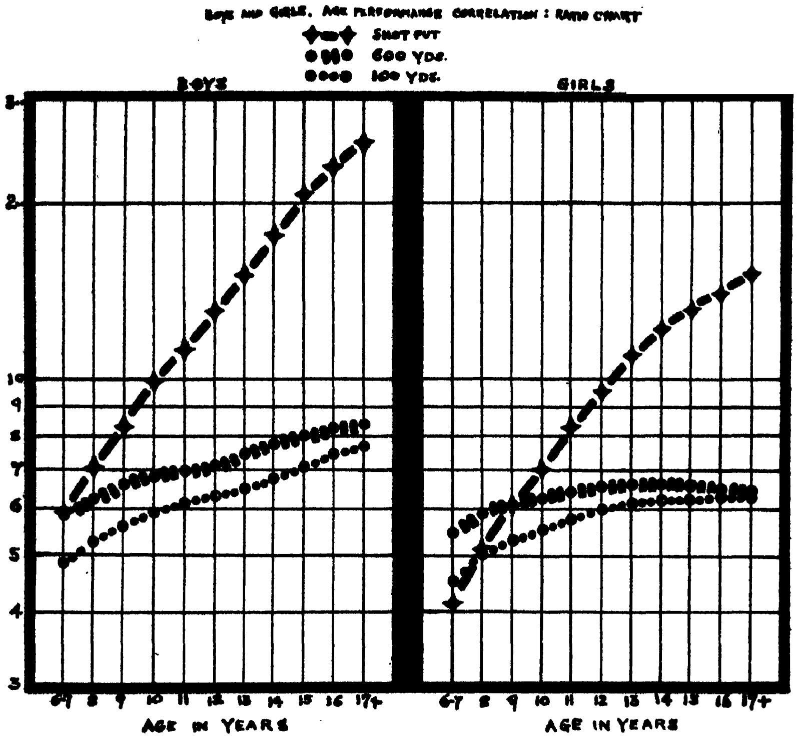
BOYS AND GIRLS. AGE PERFORMANCE CORRELATION : RATIO CHART
SHOT PUT
600 YDS.
100 YDS.
BOYS
GIRLS
3
2
10
9
8
7
6
5
4
3
6-7 8 9 10 11 12 13 14 15 16 17+
AGE IN YEARS
6-7 8 9 10 11 12 13 14 15 16 17+
AGE IN YEARS

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XXXVIII, pp.* 203-210.
January, 1942.

THE PHYSIOLOGICAL BASIS OF ENDURANCE

BY

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Read 30th June, 1941.

"What is the physiological basis of endurance"? In order to collect information on this question 32 hitherto untrained men of between 17 and 21 years of age were subjected to a three mile running test on the athletic track and to the following measurements and tests, viz.:

(1) *Anthropometric Measurements*: Height, Trunk Length, Bi-acromial Diameter, Chest Girth (Inspiration and Expiration), Chest Antero—Posterior Diameter (Inspiration and Expiration), Chest Transverse Diameter (Inspiration and Expiration), Interspinous Diameter, Intercristal Diameter, Bi-trochanteric Diameter, and Weight.

(2) *Respiration*: Respiratory Rate during Rest, Reaction of Respiratory Rate to Standard Exercise, Vital Capacity during Rest, Reaction of Vital Capacity to Standard Exercise, Breath Holding Time.

(3) *Blood Circulation*: Pulse Rate during Rest, Reaction of Pulse Rate to Standard Exercise, Blood pressure during Rest, Reaction of Blood Pressure to Expiratory Effort.

Throughout this paper all our results are stated separately for three groups called (A), (B) and (C).

(A) representing the means of tests and measurements of the *entire group* of 32 subjects.

(B) representing the means of tests and measurements of the *ten best*, and

(C) representing the means and measurements of the *ten worst* three mile runners. (Fig. 1).

Note: Details of procedure, methods and statistical treatment of results will be found in JOKL, CLUVER, GOEDVOLK and DE JONGH: Training and Efficiency; S.A.I.M.R. Johannesburg. 1941.

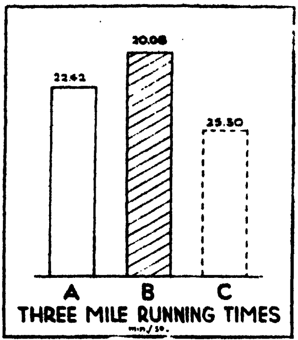


Fig. 1

RESULTS OF ANTHROPOMETRIC MEASUREMENTS.

Body Measurements. A graphic summary of the results is given in figs. 2, 3, 4 and 5. It appears from fig. 2 that the measurements of the best runners (striped columns) distinctly surpass the average level as computed from the results of the total group (straight columns). On the other hand, the measurements obtained from the worst runners (dotted columns) lie considerably below the average level. Height, trunk length and pelvic measurements of the bad runners were very much below the standard lines. The same finding was made with regard to circular and transverse chest measurements, which were much above average in the good runners.

Such observations, of course, lead us to the question whether it is possible to define positive and negative anthropometric determinators of physical efficiency.

Weight. As can be seen from fig. 3, the good runners were considerably heavier than the bad ones. The "average" level lies exactly between that of the " champions " and that of the " tail-enders."

At this stage we would like to refer to the profound differences encountered in the study of physical efficiency in *record athletes*, on the one hand, and in *ordinary young men and women* on the other. From the physiological point of view, two important facts must be kept in mind:

1. The effects of training.
2. That among highly successful athletic specialists, such as marathon champions, one deals with individuals who, in many instances, represent constitutional " freaks." Thus,

their performances may be achieved on the basis of structural and functional features which quantitatively and sometimes even qualitatively differ from the biological make-up of the average individual.

Weight, Height and Chest Standards. We have entered the measurements taken from groups (B) and (C), into a special graph constructed on the basis of standard figures as adopted by the United States Army Recruiting Office. These graphs allow an assessment not only of the absolute standards of each measurement, but they also give, for each case, an account of the relationship between the factors tested. As can be seen from figs. 4 and 5 most normal measurements lie above the minimum and parallel standard lines.

In addition, a dotted vertical line has been drawn to indicate, arbitrarily, a boundary between tall and small individuals. The more the points are situated towards the right, the taller the individuals; the higher, the heavier their bodies (fig. 4), or the larger their chest circumferences (fig. 5).

Fig. 4 indicates that the measurements of *six* of the good runners, as against *two* of the bad ones, lie on the right side of the dotted line. *Not one* of the good runners is to be found below the minimum line; of the bad runners, *one* is, in this graph, sub-standard. *Seven* of the ten good runners are on or above the " standard " weight line; i.e., that irrespective of absolute body lengths, their relative weights are satisfactory. On the other hand, only *three* of the ten bad runners are above the standard weight line.

Fig. 5 shows that the ratio: chest circumference—height is more favourable in the case of the best runners, although the difference between the " champions " and the " tail-enders " is in this case not quite as marked as in regard to the ratio: weight-height. The measurements of *six* of the ten good runners, as against only *one* of the ten bad ones, are situated on the right side of the vertical line, and above the minimum chest standard, i.e., inside the right upper quadrant. *Three* of the ten bad runners lie below the minimum chest line; the measurements of another *two* are very near this low level. Of special interest is the one case in the " champions' " group whose measurements fall distinctly below the minimum line.

It thus appears that although physique must be considered a determinator of endurance, it is definitely not the only and by no means the most powerful one. Experiences with competitive athletes show conclusively the great significance of circulation and respiration in determining standards of physical endurance. There are most probably further determinators such as temperament and intelligence.

The fact that in graphs 4 and 5 no distinct physical standard groups could be demonstrated corresponding with the considerable difference in the three mile running times of the two test groups, strongly suggests that physique is not the most important conditioning factor with regard to endurance.

Respiration. Respiratory rates and vital capacity, at rest as well as after the standard exercise test were ascertained in all three groups. With regard to respiratory rates (Fig. 6), groups A, B and C reacted in practically the same way. There were certainly no differences equivalent to those revealed in the running tests. This is, of course, a noteworthy observation.

The results of the vital capacity tests (Fig. 7) show group differences of the kind one would expect. The best runners have a higher resting vital capacity, a smaller post exercise depression and a markedly higher recovery level than the "tail-enders." The means taken from the entire group of recruits (A) lie neatly between the two extremes.

It thus appears that respiratory rate is neither a determinator, nor, alternatively, an indicator of physical endurance. On the other hand, the standard of vital capacity seems to have a bearing on certain components of working efficiency.

Blood Circulation. Fig. 8 indicates the resting pulse rates as well as the reaction of pulse rate to the standard exercise test. It can be seen that the good runners have a slightly slower resting pulse rate than the total group and the poor performers, and that the post-exercise increase as well as the level of the recovery curve of pulse rates are distinctly lower than the corresponding means from the whole group as well as from the worst runners. There is no appreciable difference between the figures obtained from the whole group and the "tail-enders."

Fig. 9 shows the results of blood pressure measurements at rest and in response to expiratory effort. At rest there are scarcely any differences between the three groups. The curves constructed from the means obtained after effort, however, indicate a slight although constant and significant difference. The champions' blood pressure level is, from beginning to end, a little higher than that of the entire group, while the "tail-enders" are below the standard This finding tends to corroborate the theory of Burger according to which outstanding athletes react to effort with a greater blood pressure rise than poor performers and asthenic persons.

The diastolic pressure curve does not show significant differences between the three tested groups.

SUMMARY.

I. Anthropometric measurements and functional tests have been undertaken with:—

(a) A group of 32 untrained recruits, many of whom were physically sub-standard.

(b) The ten best three mile runners among the above group.

(c) The ten worst three mile runners among the above group.

II. Slight but distinct differences have been revealed in most tests. The good performers showed larger measurements. Their height and weight were greatly superior to the worst performers, and practically every other anthropometric test revealed that superior athletic performances were represented by a relatively better standard of physique.

III. Of the results of the functional tests all but the measurements of respiratory rate and diastolic pressure response to expiratory effort revealed a more favourable response of the champion runners. Among the latter group we have found particularly a slower resting pulse rate, a less marked increase of pulse rates in response to exercise, as well as a higher systolic blood pressure rise after expiratory effort.

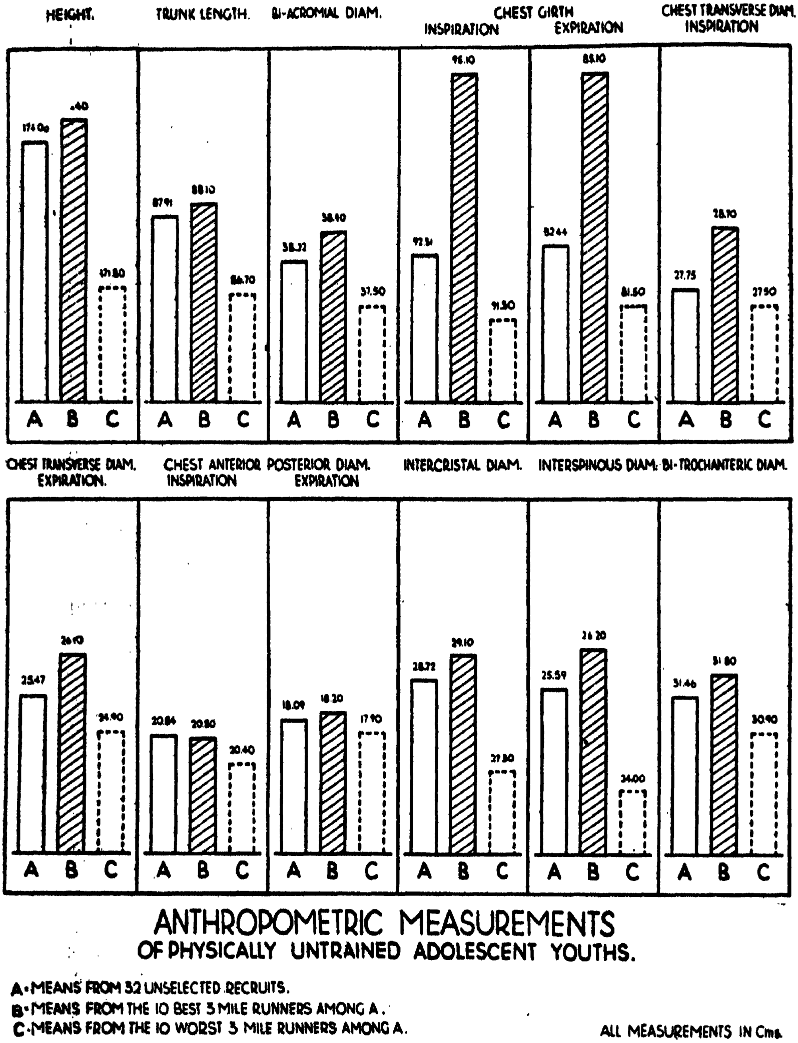

HEIGHT.
174.0o
.40
171.80
TRUNK LENGTH.
87.91
88.10
86.70
BI-ACROMIAL DIAM.
38.32
38.40
37.50
CHEST GIRTH
INSPIRATION
92.51
96.10
91.30
EXPIRATION
82.44
85.10
81.60
CHEST TRANSVERSE DIAM.
INSPIRATION
27.75
28.70
27.50
CHEST TRANSVERSE DIAM.
EXPIRATION.
25.47
26.10
24.90
CHEST ANTERIOR POSTERIOR DIAM.
INSPIRATION
20.84
20.80
20.40
EXPIRATION
18.09
18.20
17.90
INTERCRISTAL DIAM.
28.72
29.10
27.30
INTERSPINOUS DIAM.
25.59
26.20
24.00
BI-TROCHANTERIC DIAM.
31.46
31.80
30.90
A B C
ANTHROPOMETRIC MEASUREMENTS
OF PHYSICALLY UNTRAINED ADOLESCENT YOUTHS.
A-MEANS FROM 32 UNSELECTED RECRUITS.
B-MEANS FROM THE 10 BEST 3 MILE RUNNERS AMONG A.
C-MEANS FROM THE 10 WORST 3 MILE RUNNERS AMONG A.
ALL MEASUREMENTS IN Cms.

Fig. 2

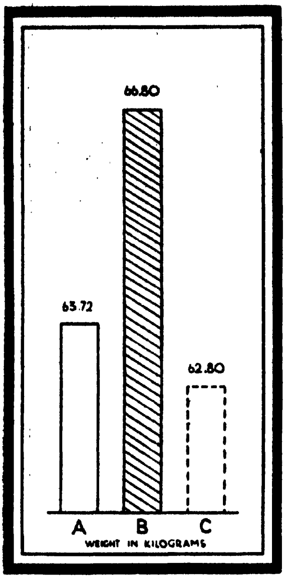


Fig. 3

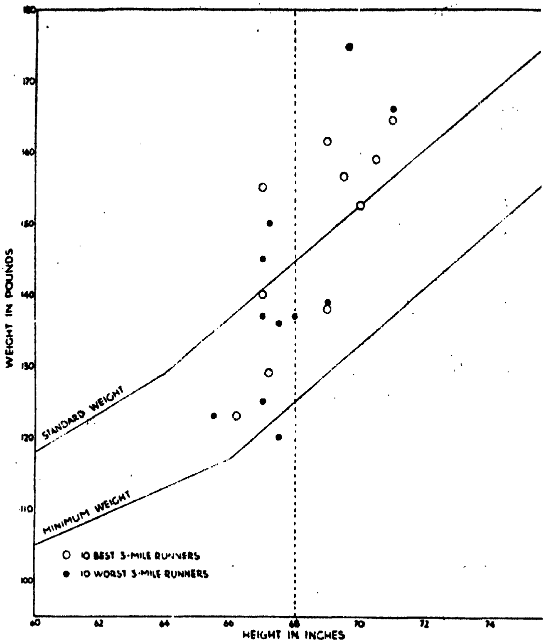


Fig. 4

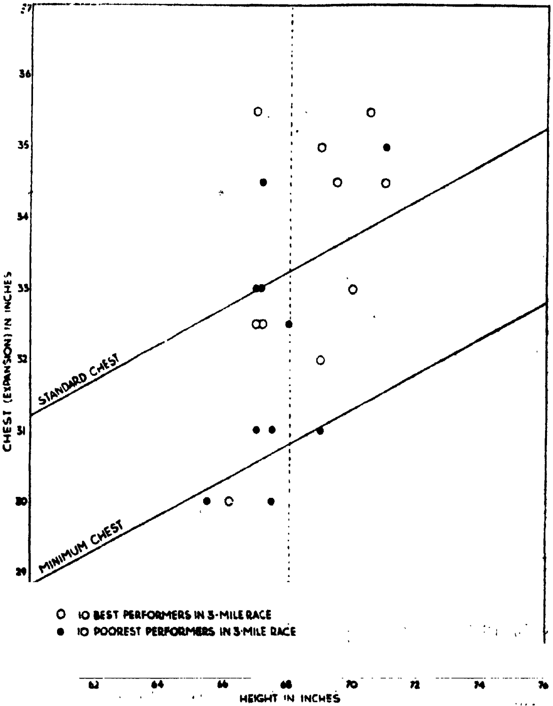
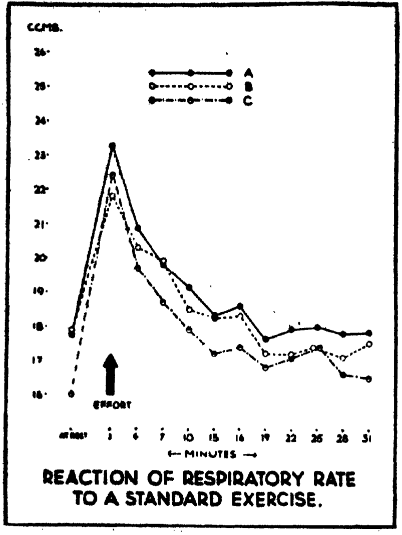
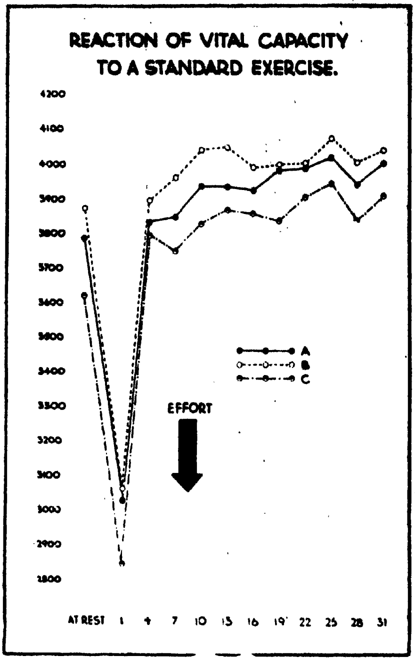


Fig. 5



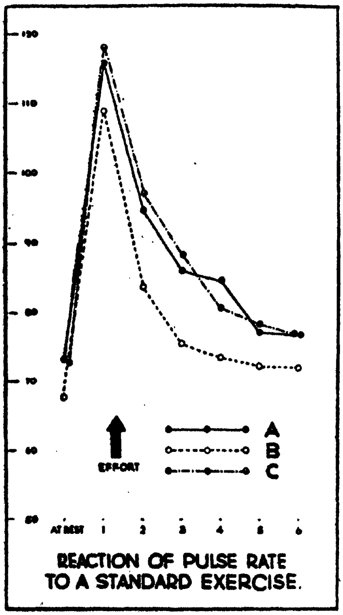
REACTION OF RESPIRATORY RATE TO A STANDARD EXERCISE.

Fig. 6



REACTION OF VITAL CAPACITY TO A STANDARD EXERCISE.

Fig. 7



REACTION OF PULSE RATE TO A STANDARD EXERCISE.

Fig. 8

BLOOD PRESSURE RESPONSE TO EXPIRATORY EFFORT.

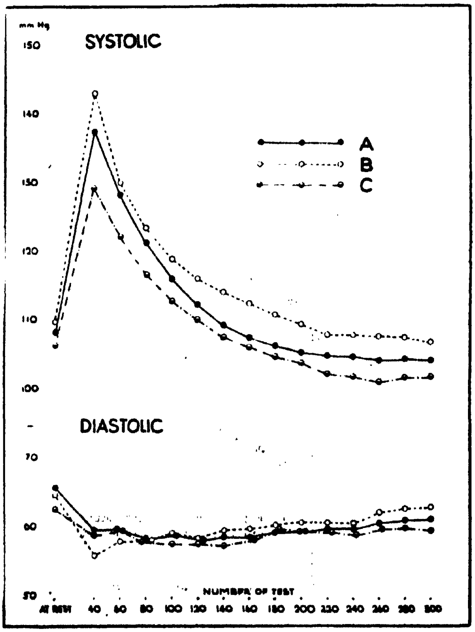


Fig. 9

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XXXVIII, pp.* 211-226.
January, 1942.

SOME PHYSIOLOGICAL SUB-DETERMINATORS OF THE REACTION OF THE HUMAN ORGANISM TO PHYSICAL TRAINING

AN ANALYSIS OF MEASUREMENTS OF 171 SOUTH AFRICAN POLICE RECRUITS,

BY

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Read 30th June, 1941.

Sufficient scientific information is to-day available to enable us to outline the physiological effects of physical training upon the development of individuals of various age groups. The effects of physical training have not, however, in all investigations been studied under conditions where exercise was the sole determining factor during the period of observation. Other influences often interfered with or modified the picture.

We feel that the stage has now been reached where it is necessary to sub-analyse the complex of reaction patterns observed in individuals undergoing physical training. It has been shown in a previous monograph (Jokl, Cluver, Goedvolk and de Jongh, 1941) that by means of such sub-analyses, morphological and functional differences of great significance can be demonstrated. We are therefore trying to isolate, experimentally, as many determinators and sub-determinators of the physiological syndrome of adjustment to repeated muscular effort as possible.

In this paper we present a critical assessment of the influence of body weight, of intensity of training and of certain performance standards, upon the chronic effects of exercise. Our study is based upon an analysis of measurements of five " troops " of thirty-six men each, which were kindly placed at our disposal by the Commissioner of the South African Police. The men who were between seventeen and twenty years of age, were stationed at the Pretoria West Police Depot where they remained for about four months.

In all instances the same standard syllabus of physical training was followed.

We wish to stress that in the above courses, the physical training was by no means the sole newly introduced influence factor. Th recruits' time-table included lectures, practical demonstrations and "drill." The number of hours devoted to physical training varied. Three troops spent, during their course, only thirty hours in physical training; the other two received between forty-five and eighty hours' instruction.

The food in the camp was very satisfactory. As a large percentage of recruits came from poor homes where dietary standards were low, it was considered likely that the camp diet alone would exert a favourable effect upon their state of fitness. By means of an analysis of measurements obtained from two sub-groups, which had received the same food but different amounts of physical training, it was possible to single out the latter factor, as against possible nutritional and other influences. The same method gave us an opportunity of assessing the degree to which pre-existing standards of physical efficiency, as well as certain body-build features act as sub-determinators, capable of influencing physiological adaptations to regular exercise.

I. MEAN RESULTS.

Table 1 shows the results of measurements undertaken *before* commencement and *after* conclusion of the four months' course. Fig. 1 depicts graphically the reactions of the trainees. The well known increases in weight, in chest circumference and in bulk of calf and upper arm muscles during training can be noticed. Abdominal circumference decreased, and thigh circumference increased, at an insignificant rate, during the course.

Fig. 1. Effects of training on police recruits.

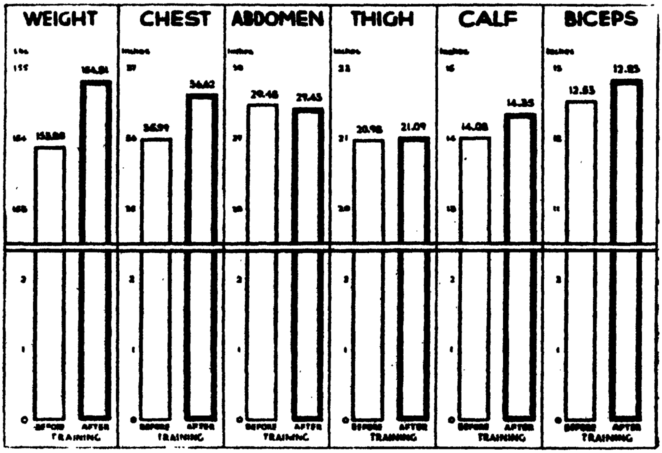

TABLE 1.—EFFECT OF TRAINING ON POLICE RECRUITS.

Measurement.	No. of Recruits.	Mean.	S. D.	P.E.M.	Difference between Means Before and After Training with Probable Errors.	Remarks on Difference.
Weight : (lbs.)						
Before Trainiag ...	171	153·88	14·75	·761		
After Training	171	154·81	13·45	·693	+·93±1·02	Increase not significant.
Chest : (Normal) (Inches)						
Before Training ...	171	35·99	1·51	·077		
After Training	171	36·62	1·62	·084	+·63± ·113	Increase significant.
Chest : (Expansion)						
Before Training ...	171	38·45	1·55	·077		
After Training	171	39·17	1·65	·085	+·72± ·114	Increase significant.
Abdomen (Inches) :						
Before Training	171	29·48	1·58	·082		
After Training	171	29·43	1·39	·071	—·05± ·104	Decrease not significant.
Thigh (Inches) : ...						
Before Training	171	20·98	1·21	·062		
After Training	171	21·09	1·13	·058	+·11± ·084	Increase not significant.
Calf (Inches) :						
Before Training	171	14·08	·850	·044		
After Training	171	14·35	·825	·042	+·27± ·060	Increase significant.
Bicpes (Inches) :						
Before Training	171	12·53	·800	·041		
After Training	171	12·83	·745	·038	+·30± ·056	Increase significant.

A comparison of the means from the entire group of 171 recruits indicates that the effects of the training were rather small, although statistically the results were significant. Corresponding figures, obtained by other investigators and by us with different groups of trainees, indicate that considerably more profound adaptations to exercise can be produced with more intense training methods.

II. Body Weight as Sub-Determinator.

We have divided the entire group of recruits into two divisions according to their weight at the commencement of the course. Group A comprises those who weighed 150 lbs. and less, while in group B are collected those who weighed more than 150 lbs. As can be seen from table 2 and fig. 2, groups A and B did not react to the training course in exactly the same way. Group A increased its weight significantly; group B lost weight. On the other hand, both groups showed an almost analogous increase in chest circumference. The abdominal measurements of group A increased slightly while those of group B decreased by almost the same amount. The thighs of group A gained a little in strength while those in B became somewhat thinner. However, calf and upper arm circumferences increased in both groups.

The results of this comparative analysis corroborate certain opinions that one of us (Jokl) had formed while teaching physical education, and in the course of clinical experiences: namely, that physical training exerts what one may best call a " regulating " influence. " The thin get fat and the fat get thin "; in our case training tended to produce " an ideal weight standard " which for the age groups under consideration appears to lie between 150 and 160 lbs. Those whose weight is below the " ideal " level are likely to show an increase, and vice versa. These observations agree with physiological experiences to the effect that being under-weight as well as over-weight are features which are detrimental to the achievement of an optimal standard of physical efficiency. A similar interpretation must be given to the observed changes of abdominal circumference (fig. 2). The " ideal " abdominal circumference in young men of the type studied by us appears to lie between 29 and 30 inches. The existence of an optimal standard of measurements of thighs (21 inches) is also indicated by our results.

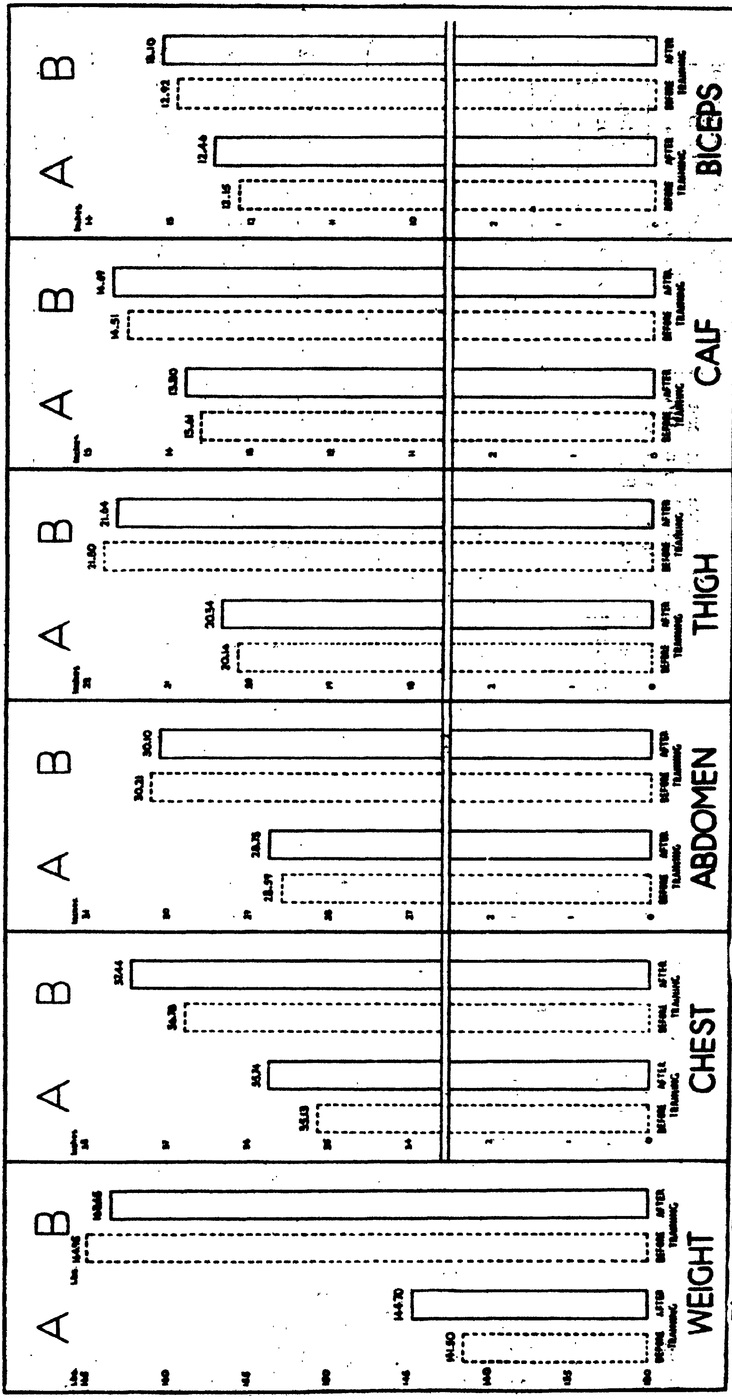

Fig. 2. Effects of training upon thin recruits (A—under 150 lbs.), and upon fat recruits (B—over 150 lbs.) respectively.

TABLE 2.—POLICE RECORDS.

COMPARING MEAN MEASUREMENTS OF GROUP A AND GROUP B.

Measurement.	No.	Mean and P.E.M.		S.D.		Difference between Means Before and After Training with Probable Errors.	Difference between Means of Group A and Group B with Probable Errors.	
		Before Training.	After Training.	Before Training.	After Training.		Before Training.	After Training.
Weight (lbs) :							(M_3–M_1)	(M_4–M_2)
Group A ...	80	(M_1) 141·50±·516	(M_2) 144·77±·563	6·84	7·47	(M_2–M_1) +3·27±·764	+23·45±·947	+18·68±·977
Group B ...	91	(M_3) 164·95±·795	(M_4) 163·45±·799	11·25	11·30	(M_4–M_3) —1·50±1·131		
Chest (Normal) :								
(Ins.) Group A:	80	(M_1) 35·13±·082	(M_2) 35·74±·092	1·09	1·23	(M_2–M_1) ± ·61± ·123	+1·65±·130	+ 1·70±·144
Group B :	91	(M_3) 36·78±·101	(M_4) 37·44±·111	1·43	1·57	(M_4–M_3) + ·66± ·150		
Chest (Expan.) :								
Group A ...	80	(M_1) 37·38±·077	(M_2) 38·21±·089	1·02	1·18	(M_2–M_1) + ·83± ·118	+ 1·87±·124	+ 1·74±·144
Group B ...	91	(M_3) 39·25±·101	(M_4) 39·95±·113	1·43	1·59	(M_4–M_3) + ·70± ·151		
Abdomen (Ins.) :								
Group A ...	80	(M_1) 28·59±·090	(M_2) 28·75±·077	1·19	1·02	(M_2–M_1) + ·16± ·118	+ 1·62±·138	+ 1·35±·121
Group B ...	91	(M_3) 30·21±·104	(M_4) 30·10±·094	1·48	1·34	(M_4–M_3) — ·11± ·140		
Thigh (Ins.) :								
Group A ...	80	(M_1) 20·14±·063	(M_2) 20·34±·061	0·84	0·81	(M_2–M_1) + ·20± ·087	+ 1·66±·091	+ 1·30±·090
Group B ...	91	(M_3) 21·80±·065	(M_4) 21·64±·066	0·93	0·94	(M_4–M_3) — ·16± ·092		
Calf (Ins.) :								
Group A ...	80	(M_1) 13·61±·049	(M_2) 13·80±·045	0·65	0·60	(M_2–M_1) + ·19± ·066	+ ·90±·074	+ ·89 ±·069
Group B ...	91	(M_3) 14·51±·056	(M_4) 14·69±·051	0·79	0·72	(M_4–M_3) + ·18± ·075		
Biceps (Ins.) :								
Group A ...	80	(M_1) 12·15±·049	(M_2) 12·46±·046	0·65	0·62	(M_2–M_1) + ·31± ·067	+ ·77±·072	+ ·64±·066
Group B ...	91	(M_3) 12·92±·053	(M_4) 13·10±·048	0·75	0·69	(M_4–M_3) + ·18± ·071		

A.—Those who weighed 150 lbs. or less before training.
B.—Those who weighed more than 150 lbs. before training.

REMARKS ON TABLE 2.

I. COMPARING THE MEAN MEASUREMENTS OF GROUP A AND GROUP B:—

Both before and after training Group B showed significantly larger measurements than Group A.

II. COMPARING THE EFFECTS OF TRAINING ON THE TWO GROUPS:—

Weight: Group A increased significantly while Group B showed a small decrease which was not significant.

Chest (Normal): Both groups increased significantly.

Chest (Exp.): Both groups increased significantly.

Abdomen: Group A showed a small increase and Group B a slight decrease, but in both cases not significant.

Thigh: Group A showed a small increase and Group B a slight decrease, but in both cases not significant.

Calf: Both groups increased but not significantly.

Biceps: Both groups increased but significantly only in Group A.

Conclusion: On the whole training had a more important effect on Group A.

As can be seen from table 3 and fig. 3, not only body weight but also abdominal circumference is of "prognostic" value with regard to the effects of physical training. Those recruits who had a "thin" abdomen gained in circumference, while the "fat" ones reacted with a significant decrease.

The discovery of an increase in chest circumference during training in both groups suggests that this reaction is a *basic* indicator of functional improvement.

Lower legs and upper arms seem generally to have been under-developed in all the recruits as may be concluded from the fact that increases of these measurements occurred in both groups.

The results of this comparative analysis prove that body weight is a powerful sub-determinator of the effects of physical training.

TABLE 3.
COMPARING ABDOMEN MEASUREMENTS OF GROUP X and GROUP Y.

	No.	Mean.	S.D.	P.E.m	Mean Difference.	Remarks on Mean Difference.
Group X :						
Before Training	110	28·53	·938	·060	+·42±·090	Significant Increase.
After Training	110	28·95	1·060	·068		
Group Y :						
Before Training	61	31·24	1·03	·089	—·82±·145	Significant Decrease.
After Training	61	30·42	1·33	·115		

X.—Those who had abdomen measurements of less than 30 inches before training
Y.—Those who had abdomen meaurements of 30 inches or more before training.

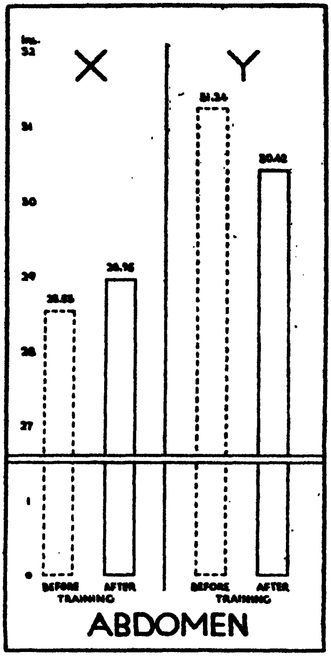

Fig. 3
Effect of training upon abdominal circumference of thin and of fat recruits respectively

III. Intensity of Training as Sub-Determinator.

An attempt was made to assess the part played by the *amount* of exercise in the production of the physiological effects of training. This question is of great practical importance in connection with the laying down of syllabuses of physical training in schools, colleges and other educational institutions. Although there is at present a general feeling that the number of physical training periods in schools should be increased, little evidence has been adduced to support and elaborate upon such demands.

We compared the reactions of thirty-six men who had about eighty hours of physical training during the four months' course (A), with another group of thirty-six who received only thirty hours' instruction during the same period (B), (Table 4 and Fig. 4).

Our results reveal that the amount of physical training per unit of time—measured in terms of months—is a most significant factor in producing physiological adaptations. In group A weight increased, while there was a decrease in group B. A significant improvement in chest circumference was evident in group A, while there was practically no reaction in group B. An increase in abdominal circumference, reflecting, under the circumstances, improvement in muscular tone and substance, was found in group A; on the other hand, there was a slight decrease in group B. As against a strengthening of the thighs in group A, there occurred a slight decrease of measurements in Group B. The latter finding indicates that not only had no muscular adjustment occurred, but that even some wasting had taken place during the period of observation. A marked improvement in the circumference of the calf and upper arm muscles was found in group A; there was no reaction in group B.

This analysis clearly demonstrates that the quantity of training per unit of time is an important sub-determinator of the physiological adjustment to repeated exercise.

COMMENT.

Group B, who received thirty periods of physical training during four months, i.e., about two periods per week, showed no physical improvement whatsoever. This finding gains in significance if we remember that, at present, most of those few school children, university students or technical apprentices in South Africa, who are lucky enough to receive physical education at all, devote one period per week to this subject. If two periods per week of the excellent exercise syllabus followed at the Pretoria West Police Depot are without developmental effect, the futility of *one* period per week of the inferior physical training, generally given at schools, is evident. Even allowing that the developmental plasticity of young children is greater than that of our adolescent recruits, the conclusion is warranted that the present official attitude towards the physical side of education urgently requires immediate and fundamental reconsideration.

One daily period of physical training, and not less, throughout school life, is necessary to achieve a level of fitness which will ensure to the individual a reasonable opportunity of living a healthful, economically mature and socially well adjusted life. Needless to say, the quality of the exercises is also a factor of great significance. However, this aspect has not been studied in the present investigation. We have confined ourselves to demonstrating that the *amount* of training is a powerful sub-determinator of those physiological processes which are responsible for the adaptation syndrome to repeated exercise.

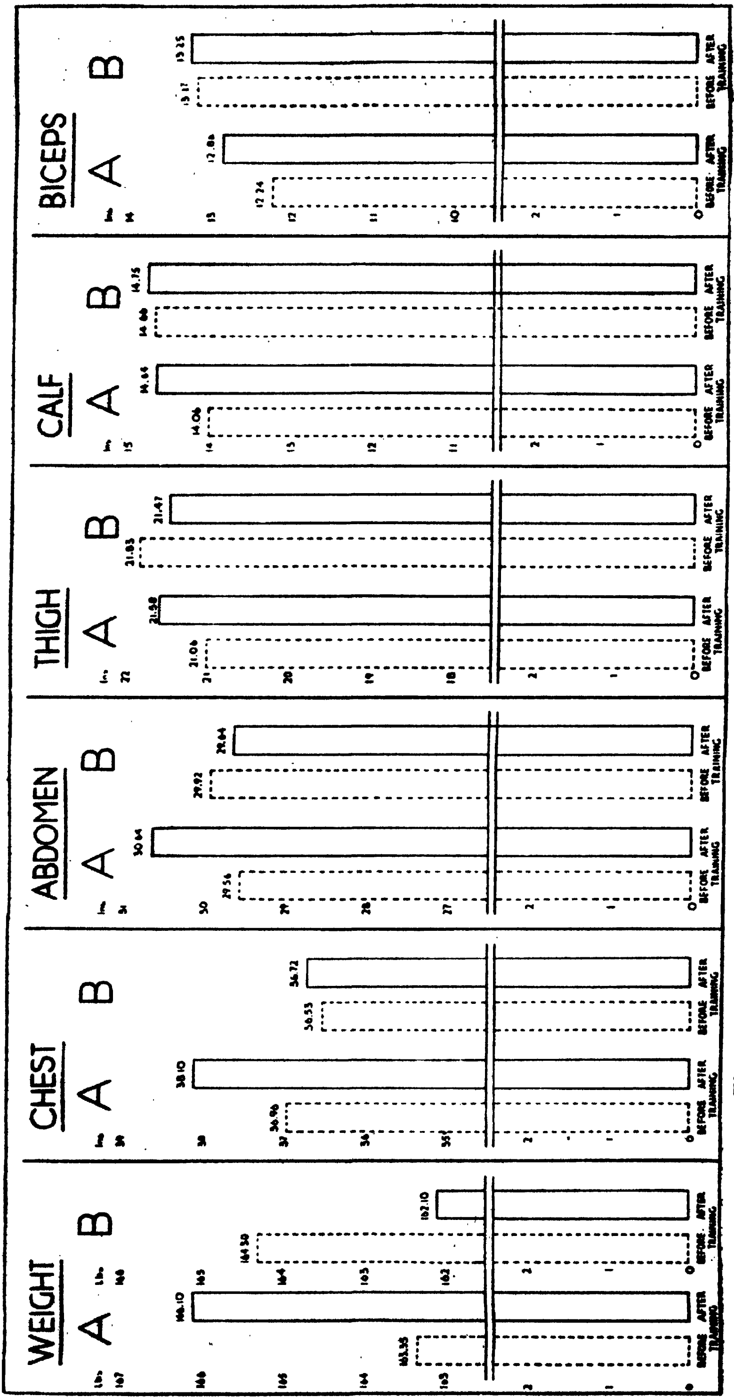

Fig. 4. Effect of little (A) and of intensive (B) training upon physical development.

TABLE 4.—POLICE RECORDS.
COMPARING THE MEASUREMENTS OF 36 MEN WHO HAD ± 80 HOURS OF TRAINING (GROUP A), WITH THOSE OF 36 MEN WHO HAD ± 30 HOURS OF TRAINING (GROUP B).

Measurement.	Before Training.			After Training.			Mean Differences with their Probable Errors.	
	Mean.	S.D.	P.E.M.	Mean.	S.D.	P.E.M		
Weight :							M_2—M_1 = +2·75 P.E.M_2—M_1 = 2·362 M_4—M_3 = —2·20 P.E.M_4—M_3 = 1·758	M_1—M_3 =— ·95 P.E.M_3—M_1 = 2·161 M_2—M_4 = +4·0 P.E.M_2—M_4 = 1·938
Group A ...	163·35 (M_1)	15·10	1·697	166·10 (M_2)	13·90	1·562		
Group B ...	164·30 (M_3)	11·90	1·337	162·10 (M_4)	10·15	1·141		
Chest (Normal) :							M_2—M_1 = +1·14 P.E.M_2—M_1 = ·284 M_4—M_3 = + ·19 P.E.M_4—M_3 = ·178	M_1—M_3 = + ·43 P.E.M_1—M_3 = ·235 M_2—M_4 = +1·38 P.E.M_2—M_4 = + ·238
Group A ...	36·96 (M_1)	1·785	·200	38·10 (M_2)	1·803	·202		
Group B ...	36·53 (M_3)	1·117	·125	36·72 (M_4)	1·133	·127		
Chest (Expan.) :							M_2—M_1 = +1·30 P.E. M_2—M_1 = ·309 M_4—M_3 = + ·50 P.E.M_4—M_3 = ·192	M_1—M_3 =— ·08 P.E.M_1—M_3 = ·263 M_2—M_4 = + ·72 P.E.M_2—M_4 = ·251
Group A ...	39·06 (M_1)	2·034	·229	40·36 (M_2)	1·858	·208		
Group B ...	39·14 (M_3)	1·158	·130	39·64 (M_4)	1·254	·141		
Abdomen :							M_2—M_1 = +1·08 P.E.M_2—M_1 = ·289 M_4—M_3 =— ·28 P.E.M_4—M_3 = ·190	M_1—M_3 =— ·36 P.E.M_1—M_3 = ·265 M_2—M_4 = +1·0 P.E.M_2—M_4 = ·222
Group A ...	29·56 (M_1)	1·942	·218	30·64 (M_2)	1·694	·190		
Group B ...	29·92 (M_3)	1·342	·151	29·64 (M_4)	1·031	·116		
Thigh							M_2—M_1 = + ·52 P.E.M_2—M_1 = ·177 M_4—M_3 =— ·36 P.E.M_4—M_3 = 166	M_1—M_3 =— ·77 P.E.M_1—M_3 = ·197 M_2—M_4 = + ·11 P.E.M_2—M_4 = 174
Group A ...	21·06 (M_1)	1·384	·156	21·58 (M_2)	1·163	·131		
Group B ...	21·83 (M_3)	1·081	·121	21·47 (M_4)	1·013	·114		
Calf :							M_2—M_1 = + 58 P.E.M_2—M_1 = ·123 M_4—M_3 = + · 09 P.E.M_4—M_3 = ·126	M_1—M_3 =— ·60 P.E.M_1—M_3 = ·131 M_2—M_4 =— ·11 P.E.M_2—M_4 = ·118
Group A ...	14·06 (M_1)	·827	·093	14·64 (M_2)	·727	·081		
Group B ...	14·66 (M_3)	·824	·093	14·75 (M_4)	·764	·086		
Biceps							M_2—M_1 = + ·62 P.E.M_2—M_1 = ·121 M_4—M_3 = + ·08 P.E.M_4—M_3 = ·086	M_1—M_3 =— ·93 P.E.M_1—M_3 = ·108 M_2—M_4 =— ·39 P.E.M_2—M_4 = ·102
Group A ...	12·24 (M_1)	·803	·090	12·86 (M_2)	·720	·081		
Group B ...	13·17 (M_3)	·546	·06	13·25 (M_4)	·553	·062		

REMARKS ON TABLE 4.

1. *Weight*:

No significant increase in Group A or decrease in Group B, nor significant differences between the two groups before or after training. (It is nevertheless interesting to note that Group A showed a tendency to increase in weight, while Group B showed a tendency to decrease.)

2. *Chest (Normal)*:

Group A: Increased significantly.
Group B: No significant increase.

While the two groups did not differ significantly *before training*. Group A was significantly larger than Group B *after training*.

3. *Chest (Exp.)*:

Group A: Significant increase.
Group B: No significant increase.

No significant differences between the two groups before or after training.

4. *Abdomen*:

Group A: Increase close to border of significance.
Group B: No significant increase.

While the two groups did not differ significantly *before training* Group A was significantly larger than Group B *after training*.

5. *Thigh*:

Group A: Increase not significant.
Group B: Decrease not significant.

While Group B was significantly larger than Group A *before training*, there was no such difference *after training*.

6. *Calf*:

Group A: Significant increase.
Group B: No significant decrease.

While Group B was significantly larger than Group A *before training*, no such difference existed *after training*.

7. *Biceps*:

Group A: Significant increase.
Group B: No significant increase.

While Group B was significantly larger than Group A *before training*, this was no more the case *after training*.

Conclusion:

The general conclusion can safely be drawn that training had a far more important effect on Group A than on Group B; this, of course, being due to the fact that the former had nearly 3 times as many hours of actual physical training than the latter.

IV. PHYSICAL EFFICIENCY AS SUB-DETERMINATOR.

Of the 171 men, we selected thirty-five who were good or outstanding athletes when they joined the Police Force, and calculated the means of their measurements. (Table 5). In fig. 5 we have plotted the results of this analysis (B) alongside the measurements of the entire group of 171 (A).

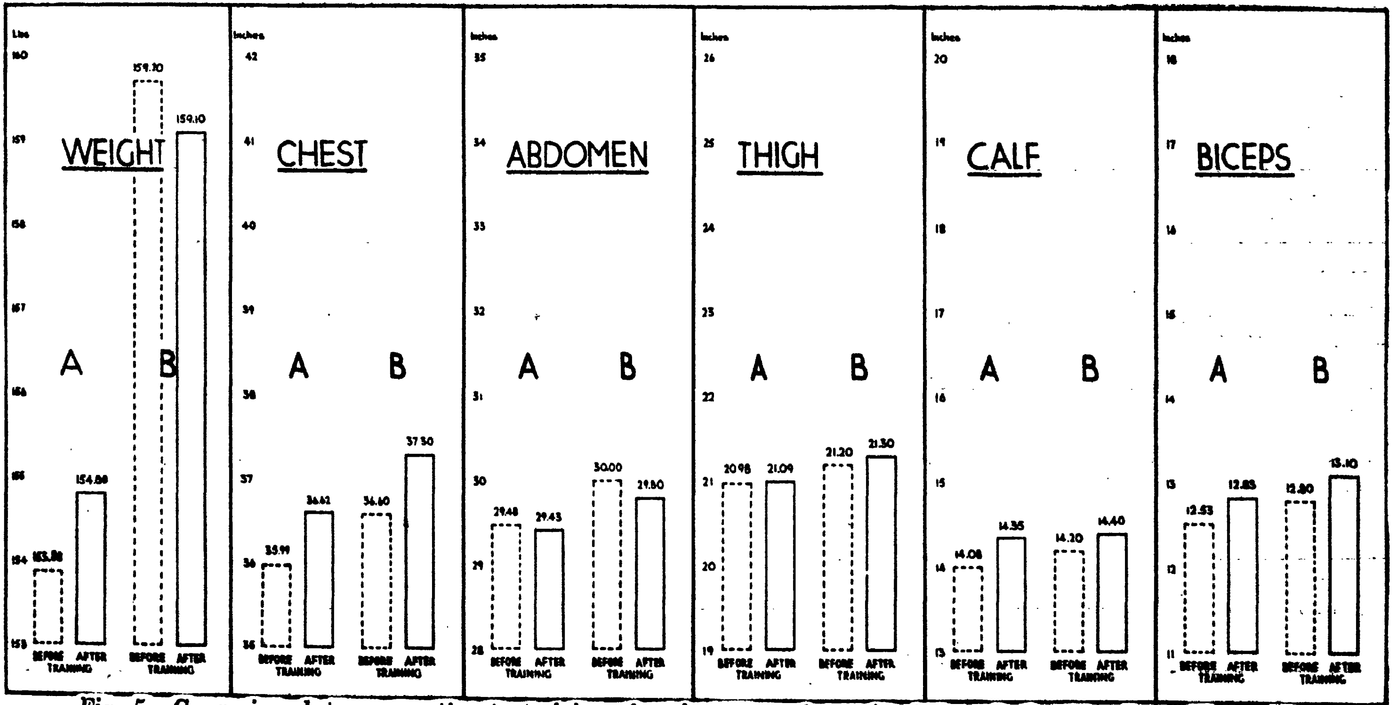

Fig. 5. Comparison between reaction to training of entire group of recruits (A), and of outstanding athletes (B).

TABLE 5.—POLICE RECORDS.
35 OUTSTANDING AND GOOD ATHLETES.

Measurement.	Before Training.			After Traiining.			Mean Difference and Probable Error.
	Mean	S.D.	P.E.M	Mean	S.D.	P.E.M	
Weight	159·7	13·40	1·528	159·1	12·70	1·448	—·6± 2·15 Decrease not significant.
Chest (Normal)	36·6	1·46	·167	37·3	1·64	·187	+ ·7 ± ·251 Increase not significant.
Chest (Expansion)... ...	39·2	1·56	·178	40·2	1·65	·188	+1·00± ·258 Increase close to significant.
Abdomen	30·0	1·55	·177	29·8	1·48	·169	— ·2 ± ·244 Decrease not significant.
Thigh	21·2	1·09	·012	21·3	1·02	·011	+ ·1 ± ·014 Significant increase.
Calf	14·2	·85	·009	14·4	·84	·009	+ ·2 ± ·012 Significant increase.
Biceps	12·8	·75	·009	13·1	·73	·008	+ ·3 ± ·012 Significant increase.

It can be seen at a glance that the measurements of the "athletes" are distinguished from those of the average. When the "athletes" arrived at the camp, they were 6 lbs. heavier than the rest. They seemed to have already reached an optimal weight standard, as may be judged from the fact that they neither gained nor lost during the four months at the camp. This result, however, does not by any means indicate that no processes of adaptation to exercise had occurred. Their chest girth increased; their abdominal circumference decreased a little. Muscular measurements, as reflected by the circumference of thigh, calf and upper arm, increased slightly.

The "athletes" were superior to the average recruit with regard to every factor tested. Moreover, their measurements lay closer to the "ideal levels," as suggested by the sub-analysis of the body weight groups in part II of this paper. The general trend of the physiological adjustments during training, however, was the same in both groups.

COMMENTS.

The result of this sub-analysis has a distinct bearing upon the question of "conditional training" for competitive athletics. In the "olden days," a swimmer swam, a runner ran and a wrestler wrestled. Training for a competitive event consisted of continuous repetition of the same specially chosen activity. More recently the introduction of scientific methods into sport has acquainted coaches and athletes with the practical significance of the "transfer phenomenon": it is now understood that gymnastic exercises which apparently only serve to make the muscles "supple and skilful," somehow lead to an improvement of the speed of the sprinter; that cross-country running which apparently improves "the wind" only, helps a wrestler to win his bouts; and that weight lifting which apparently influences strength alone, is of benefit to the high jumper and to the swimmer. In other words, it is now realised that there exists a physiological basis of efficiency on which specialised performances must be, as it were, superimposed. It is true, outstanding talent sometimes seems to cut across these biological rules. A "born" strong man may excel as a weight lifter without having undergone systematic physical training. Louis won the marathon race at the 1896 Olympic Games in Athens without having ever practised running. On the other hand, the amazing progress of performance standards and athletic records during the last two decades, as well as the fact that more recently " newcomers " are no longer able to win sport competitions, indicates that even the most outstandingly gifted individual must first improve his performances through systematic physical training before he can be successful. We have recently shown, for the first time, that *a high standard of physical efficiency in a hitherto untrained person is an indication of a great physiological potential of adaptation rather than a sign of outstanding organic development.*

In our group of " athletes," marked adaptive changes were produced by a very mild course of physical training. This result represents valuable corroborative evidence with regard to our thesis that every competitive athlete must undergo a course of *primary* physical training before he takes part in special events. This primary training must include activities other than those in which he will ultimately specialise. Special training is *secondary* training. This secondary training must be superimposed on a basis of elementary physical fitness built up through a well balanced syllabus of muscular activities demanding skill, strength and endurance.

SUMMARY.

Quantitative evidence has been adduced to the effect that the following factors are capable of acting as powerful sub-determinators of the adaptive changes induced by repeated physical exercise.

1. Body weight.
2. Intensity of training.
3. Physical efficiency.

The practical implications of our observations are discussed.

Grateful acknowledgment is made to Col. Baston, Commissioner of the South African Police, and Head Constable Rootmann of the Pretoria West Training Depot for collaboration in this research.

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THE SUPPORT REACTION AND THE CENTRAL NERVOUS CONTROL OF PROGRESSION

BY

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Introduction.

Magnus (1924) had originally drawn attention to the fact that the structural anatomy of the extremities of animals enables them to carry out a rich diversity of patterns of movement. While this anatomical arrangement provides for great mobility, it does not permit of the limb being used for purposes of support unless specifically integrated muscular forces are brought into action to convert the plastic extremity chains into fixed pillars. Magnus and his collaborators showed that the central nervous system controls a number of static reflexes, which are concerned in this transformation of the extremities from highly mobile into rigid structures or vice versa, as required. The support reaction proved to be one of the most important of these nervous control mechanisms.

The original analysis of this reflex phenomenon was carried out on de-cerebellate animals. The support reaction has since been shown to appear in animals also after irritative or destructive lesions distributed over a wide variety of situations in the central nervous system. (Stenvers, 1936; Rademaker, 1937).

Magnus showed that if a dog stands, or if pressure is applied to the pads of his feet, dorsi-flexion occurs at the inter-phalangeal, as well as at the wrist and ankle joints; the flexor muscles of the feet are passively stretched. In the de-cerebellate animals this sets up a pattern of co-ordinated reflex muscular contraction which leads to a static fixation of the limbs in extension. Thus the dog is able to support itself on all fours. (Proprioceptive support reaction).

Passive flexion at the interphalangeal and wrist joints causes stretching of the extensor muscles. This leads to a sequence of reflex muscular contractions resulting in general flexion of the limb. That flexion will be rigidly maintained as long as the foot is kept flexed. The rigid fixation of the limbs in extension or flexion can be overcome only by releasing the pressure on or the cutaneous contact with the palmar (plantar) and volar surfaces of the paws respectively.

It is not always necessary to stretch the flexor muscles of the extremity in order to provoke and maintain this forcible extensor reflex. Cutaneous irritation of the plantar or palmar surfaces may suffice. This latter phenomenon has been called by Magnus " magnet reaction." It would seem that this exteroceptive mechanism is commonest in de-cerebellate animals. The proprioceptive support reaction occurs predominantly in cases in which the brain injury is located elsewhere than in the cerebellum.

The phase of forcible extension is called the positive support reaction, the flexion phase the negative support reaction. Both the positive and the negative support reactions are each characterised by two different dynamic components. There is a static component during which rigid fixation of the limb in extension or flexion respectively is maintained; and a kinetic component which corresponds with the phases of the compulsory movement patterns that lead to the attainment of the static position of the limbs.

In the comparatively short period which has elapsed since Schwab (1927) discovered the support reaction as a clinical phenomenon, several case reports and other papers dealing with the significance of this neurological mass reflex have been communicated. These have been satisfactorily reviewed by Balduzzi (1932) and Stenvers (1936). As a clinical phenomenon the support reaction is, therefore. already well known. Its pathology, however, remains somewhat obscure and its significance has not yet been finally assessed.

An analysis of the clinical signs associated with the support reaction, as observed in our case, has shed considerable light on the significance of the reaction. But the application of the information obtained in this manner does not cease here. A study of the neuro-pathology of movement of which the support reaction, as well as loss of arm swinging during walking, are impressive examples, entails investigation into the nervous mechanism of posture and progression, i.e. of the two most fundamental kinesiological problems. The information obtained in the course of this analysis has also rendered it possible to understand certain broader aspects of the neurological mechanism underlying normal motor activity.

CASE HISTORY.

General Features: A male Swazi labourer, aged 37 years, was admitted to the Johannesburg Non-European Hospital on 24th June, 1938, with a history of having fallen twenty feet from a building. He struck the pavement with his forehead. Apparently there was no unconsciousness or amnesia. Complete aphasia had developed a few hours after the accident and was present at the time of the first clinical examination. There was bleeding from the right ear and the patient repeatedly vomited.

A cursory clinical examination at the time of admission revealed that the patient had escaped serious internal injury. There was a depressed fracture of the forehead, situated one inch above the glabella and one inch to the right of the midline. Body temperature fluctuated between 96.5—98.4° Fahrenheit; pulse rate varied from 60—72 beats per minute, and respiratory rate ranged on various occasions from 18—22 per minute. There appeared to be motor aphasia; the right pupil was wider than the left; both pupils failed to react to light and on accommodation. Fundi were normal. There was a paresis of the lower parts of the right side of the face, leading to asymmetry of the mouth. Other cranial nerves showed no abnormality, and no disturbances of sensation were detected. A Babinski sign could be elicited on the left, on which side the knee jerk was greatly exaggerated. Both the upper and lower right extremities were paretic, and movements appeared inco-ordinated.

The Wasserman reaction of the blood was negative. Lumbar puncture three days after admission revealed a clear fluid at a pressure of 100 mm. water. The aphasia improved considerably after the first lumbar puncture, and repetition of this operation two weeks later was followed by its complete disappearance. The patient now considered himself so well that he demanded his discharge. (10.7.38).

A few weeks later (3.8.38) he was readmitted complaining of dizziness on stooping, of great difficulty in walking, and severe pains extending over the head, mouth, throat, back and over the inner sides of both thighs.

Examination at that date revealed that the right pupil was larger than the left; both pupils reacted very sluggishly to light. There was hyperaesthesia and hyper-algesia of the right side of the scalp, face, neck and shoulder; there was facial paresis on the right side. There was hyperactivity of all tendon and periosteal reflexes, although knee and ankle jerks were more exaggerated on the left side; there was marked paresis of the right upper and lower extremities.

After another lumbar puncture the hyperaesthesia improved, and the patient was greatly relieved of the pain in his head, mouth, throat, back and legs. He subsequently left the hospital, but was readmitted on 9.11.38, complaining of headache, giddiness on bending forward, and of vomiting. Examination of the nervous system now revealed that the right pupil was larger than the left and irregular, and that both pupils reacted sluggishly to light and on accommodation. *Both fundi showed papilloedema.* There was hemianaesthesia with astereognosis on the right side. The right extremities were paretic; knee and ankle tendon reflexes were considerably exaggerated on the left side. Biceps and triceps jerks were brisk on both sides, although the response was greater on the left. No spastic reflexes were present. Abdominal and cremasteric reflexes were diminished on the right side. Lumbar puncture revealed clear cerebro-spinal fluid at a pressure of 300 mm. water. The Wasserman reaction of the cerebro-spinal fluid was negative; there were 12 erythrocytes per c.c.; chloride concentration was 720 mgm. per 100 c.c. (as NaCl); sugar 65 mgm. per 100 c.c.; globulin was not present in excess; Lange's colloidal gold test gave a negative result. The Wasserman reaction in the blood was again negative. Blood count: haemoglobin 94%; colour index 1; erythrocytes 4,700,000; leucocytes 5,400; neutrophils 46.5%; monocytes 6.0%; eosinophils 6.0%; lymphocytes 41.5%; basophils not present; urine was alkaline, sp.gr.1024; no sugar.

On 19.11.38, Mr. A. Lee McGregor performed a trepanation under nitrous oxide anaesthesia. A large temporal bone flap was raised on the left side. An area of approximately one square inch of the anterior, superior edge of this flap corresponded with a depressed fracture which slightly overlapped. Beneath this flap the dura mater was found to be intact. After incising the dura, gossamer adhesions had to be separated between dura and brain, whereafter *a violaceous contusion about one square inch in extent was discovered.* No brain tissue was excised; the larger part of the trepined bone was replaced and the wound was closed. There was mild fever and tachycardia for a period of two weeks following the operation, whereafter the wound had healed. At this stage (26.11.38) a support reaction was discovered.

THE SUPPORT REACTION IN OUR CASE.

The support reaction could be elicited as a proprioceptive reflex on the left arm. Both positive and negative phases were demonstrated, and the kinetic, as well as the static components were represented in both parts of the reaction (Figure 7, a to d). Hyperextension of the hand (Figure 7, b) led to a forcible extension movement of the whole arm (Figure 7, c) which subsequently formed a rigid pillar (Figure 7, d). The arm could then not be flexed without undue application of force. However, if the hand was flexed, flexion could easily be effected at the elbow joint. If the hand was flexed ad maximum, a forcible mass flexor movement occurred at the elbow and shoulder joints (Figure 7, a). From this position, which represents the static phase of the negative support reaction, extension of the arm could not be effected. If, however, the hand was passively extended, the kinetic component of the positive support reaction was promptly elicited, and a powerful extensor thrust of the arm resulted. (Cinematographic records of the support reaction, as well as of the arm-swinging movements during walking (see later) were taken, and can be seen at the Witwatersrand Technical College.)

There was a noticeable postural influence in that rotation of the head led to an increase of extensor tone in the chin arm, with a simultaneous decrease of flexor tone on the same side. Increase of flexor tone occurred in the occiput arm with simultaneous decrease of extensor tone. Flexion and extension of the head had no effect upon the reaction.

Dorsal flexion of the left foot led to a noticeable increase of extensor tone of the entire leg, while plantar flexion of the foot was followed by an increase of flexor tone. However, neither the kinetic nor the static phase of the support reaction proper was present.

The reaction could be demonstrated in the left arm during a period of two and a half months, whereafter it could no longer be elicited.

NEUROLOGICAL FOLLOW-UP EXAMINATION.

At a final neurological examination performed on 18.3.39, the patient's condition was as follows: The skull showed an area of rough irregularity on the surface of the right frontal bone, one inch above the glabella and one inch to the right of the midline. In the temporoparietal area the sequelae of the operation were conspicuous X-ray pictures of the skull showed the extent of the bony defect. (cp. figure 5, a and b).

Intelligence, attention, memory and reasoning powers were well within the range of normality for a negro. Emotional reactions seemed to be normal. No intellectual abnormalities were noticeable. Speech was not very distinct, though the patient himself considered that he could speak quite normally. Neither unusual motor behaviour nor apraxia were observed. The patient is right handed.

Investigation of the cranial nerves revealed that visual acuity was diminished on the right side, but that visual function of the left eye was unimpaired. Fields of vision were normal for both moving and stationary objects. No evidence of colour-blindness was found. The optic discs and fundi showed no abnormality. The range of external ocular movements was normal, and there was no strabismus There was bilateral horizontal nystagmus, most noticeable when the eyes were turned to the extreme right, consisting of a slow movement to the left, followed by a rapid stroke to the right. The right pupil was 5 mm., the left 3 mm. in diameter and irregular. Both pupils reacted very sluggishly to light and on accommodation. Consensual reactions were present. The cilio-spinal reflex was absent.

The masseter, temporal and pterygoid muscles functioned normally. The patient complained of hyperaesthesia over an area of the right side of the face, the extent of which is shown in figure 3. Hearing was normal on the left, but impaired on the right side. Bone conduction was only slightly better than air conduction. The protruded tongue did not deviate. There was an area of complete analgesia and anaesthesia of the right hand (figure 3), while conception for touch, temperature and pain were diminished over the entire arm and parts of the shoulder (figure 3). An area of complete anaesthesia, analgesia and athermaesthesia extended over the anterolateral region of the lower part of the right leg, as well as over the calf including the lateral malleolus, the dorsum and the medial half of the sole of the foot (figure 3). There was complete astereognosis of the right foot (figure 3), and of the right hand, while tactile discrimination was diminished on the entire right side of the body. Vibration was normally felt, and joint sense was unimpaired.

Muscular strength of the hands was diminished on the right side. Contraction power and the tone of muscles at hip, knee and ankle were diminished on the right side. There was a slight degree of dysdiadochokinesis and dysmetria of the right arm. The biceps, triceps and supinator reflex responses were weaker on the right side. Léri and Mayer reflexes could be demonstrated on both sides. The right knee and ankle jerks were diminished. Again, no spastic reflexes could be elicited. There were no trophic disturbances, and no functional abnormalities of the autonomic nervous system were detected.

ASSOCIATED ARM-SWINGING MOVEMENTS.

In the course of our investigation of this case our attention had been directed to disturbances of the arm-swinging movements. As is well known, disturbances of the pendular movement of the arm often occur as an early sign of cerebellar disease. It has been suggested by both Halpern (1939) and Wartenberg (1939) that the effect of frontal lobe lesions upon arm-swinging movements should be studied in order to clarify the physiological relationship between the cerebellum and the cerebrum.

We found in our case marked impairment of the associated arm-swinging movements on the right, i.e. on the contralateral side. The normal rhythmical co-movements of the arm were practically absent, the arm being kept almost rigidly at the side during all the phases of walking. Only at the commencement of the walking did the right arm perform associated movements of a clumsy inco-ordinated character. The left (homolateral) arm moved normally.

Figures 10 (a) and 10 (b) indicate the rigidly adducted position of the right arm, as compared with the normal abducted phase of the movements of the left arm. The moment chosen for comparison is that in which the arm swings past the body, describing a semi-circular excursion movement. This action represents a normal constituent of the associated arm-swinging movement. Owing to the above described motor disturbance, the right arm of our patient appears longer in the photographs than the left. From figures 11 and 12 the amplitude of the forward and backward excursion of the normally moving arm can be judged exactly; the same figures demonstrate the corresponding phases in the movement of the right arm, revealing the marked restriction of the amplitude of its swing.

An observation to which we attach importance is a rhythmical contraction of the triceps and biceps of the involved right arm of our patient. No such contraction was recognisable on the normal left side. Triceps contraction occurred on the right side whenever the left (normally moving) arm commenced swinging forwards. Right biceps spasm, on the contrary, was observed at the moment when the left arm started swinging forwards, i.e. when the right arm would ordinarily have begun to swing backwards.

The braking effect of these muscular contractions fully explains the suppression of arm-swinging on the right side. (See also Hubbard and Stetson, 1938.) This defect of the arm swinging movement has been found to be still present twenty months after the initial injury was inflicted.

DISCUSSION.

SPECIAL FEATURES OF OUR CASE OF SUPPORT REACTION

Our case is the first recorded example of the support reaction of traumatic origin. It is also the first case observed in a negro.

The association of motor aphasia due to a circumscribed left sided cerebral cortical lesion with ipsilateral support phenomenon has previously been recorded by Balduzzi (1932). At the time of the first appearance of the support reaction, our patient experienced serious difficulty in standing and walking. This phenomenon was reminiscent of the loss of reflex standing associated with the appearance of other static disturbances in the dog after section through the upper half of the mesencephalic tectum (Brücke, 1937).

There is no previous record of the simultaneous appearance of ipsilateral support reaction and contralateral loss of arm-swinging movement in walking following a circumscribed cortical injury. Our observation of the combined occurrence of these two signs throws new light on the subject of walking.

DIAGNOSTIC SIGNIFICANCE OF THE NEUROLOGICAL SYMPTOMS.

In previously published cases of support reaction there has often been considerable doubt as to the exact localization of the cerebral lesions (Stenvers, 1936). Very few associated neurological signs and focal symptoms were described. Our case seems to be the first to supply information on the question of cerebral localization of the support reaction

A circumscribed lesion so serious as to modify the reflex tonus of the limbs on one side of the body, as well as to affect the arm swinging movements on the contralateral side, must necessarily involve well known cerebral mechanisms.

A host of symptoms and signs were recorded in our case at various times. The majority of these were present since the first examination and have persisted ever since. Others made their appearance at a later date, while further symptoms were of a temporary nature. Transient were the right sided hemianaesthesia and hemiparesis; the pain in the head, throat, mouth, back and inner aspects of the thighs, the motor aphasia, the Babinski sign; and the exaggerated knee. ankle, triceps and biceps tendon reflexes on the left side. All these symptoms disappeared after lumbar punctures.

As acute head injuries are frequently accompanied by a variety of neurological signs caused by congestion, ischaemia. oedema and other temporary tissue reactions, it may be argued that no localising significance can be attached to some of these symptoms. Had they been completely unrelated to those reactions, which persisted or appeared later, this contention would certainly be justified for our case. However, many of our patient's initial symptoms readily fit into the picture as it appears in the light of subsequent observations. They, therefore, indicate that an extensive zone of the brain was involved by the injury, but that only a smaller circumscribed cortical area remained permanently damaged.

The unilateral ocular signs which our case presented may all be accounted for by the cortical injury. Kleist (1936, p. 580) refers to cases of nystagmus, due to frontal lobe lesions, which probably involved the fronto-pontine tracts; or lesions of the visual cortex. He records cases of pupillary inequalities and interference with the light and accommodation reflexes, as well as cases of contralateral pupillary dilation caused by pure frontal lobe cortical lesions (p. 582). If, as in our case, nystagmus is found in association with ocular signs other than conjugate deviation, the lesion is more likely to be cortical in origin than mesencephalic. Kleist shows further that ocular symptoms of mesencephalic origin are almost always bilateral, while unilateral symptoms often indicate cortical lesions.

The last symptom which requires discussion is the spontaneous pain in the head, neck, mouth, throat, back and thighs. The pain occurred shortly after the accident and was relieved by lumbar puncture. We consider that this bilateral symptom was of a thalamic origin. All motor signs were unilateral. The facial paresis was of a cortical type, and there was a transient aphasia. All these observations point to a lesion of the left cerebral cortex.

The disturbance of the associated arm-swinging movements during walking persisted after most of the pyramidal signs had disappeared. Spasticity of the right arm was never in evidence. In the absence of other signs of cerebellar involvement, it is obvious that this sign is caused by the left sided injury of the frontal cortex. Similar observations of disturbances of associated arm swinging movements have now been communicated by Halpern, who, however, does not mention whether a support reaction was present in his two cases.

The support reaction is a homolateral phenomenon. That it was found in our case on the left side is final evidence of the left-sided cortical origin of the neurological syndrome as observed in our patient.

THE SPECIFIC SIGNIFICANCE OF THE NEUROLOGICAL FINDINGS IN CORTICAL LOCALISATION.

We have traced the outlines of the skull as shown on lateral view X-ray plates. These plates indicate the depressed area, and permit an estimate of the extent of the brain injury (figure 13). The large darkly shaded portion represents the area of trepanation, which corresponds with the field of violaceous contusion of the brain. Chiene's lines were superimposed on the outline tracing of the skull, and the typical distribution of the important cortical areas was indicated to show their relationship to the traumatic lesion.

It immediately became obvious to us that Chiene's lines are not suitable topographical indicators in cases of negro skulls. Neither Krönlein's nor Kleist's guide lines devised to determine cranio-cerebral topography, yielded better results. The obvious reason is that the negro calvarium is fundamentally different from that of a European, and that it contains a differently shaped brain. To overcome this difficulty we devised another method. From a collection of seventy life-size photographs of South African negro brains, a typical example of a male Swazi brain was selected. It fitted neatly into the X-ray tracing of the skull of our patient. The main sulci and gyri of this brain were identified and a tracing was superimposed on the skull outlines (figure 14). Chiene's lines were again included and their unsuitability for use in the topographical identification of cerebral elements in the Bantu brain was finally proved.

The area of cortical injury in our case now coincided with the following gyri:—

The posterior margin of the inferior frontal convolution (posterior to pars basilaris); the posterior portion of the middle and superior frontal gyri; the upper anterior portion of the anterior central gyrus. The continuation of the fracture line of the skull corresponded with a narrow cortical zone extending backwards across the upper third of the posterior central gyrus, along the lower edge of the superior parietal lobule just above the intra-parietal sulcus and across the post-parietal gyrus.

It is now generally agreed that areas of cortical localisation correspond broadly to clearly recognisable gyri. Cortical areas of specific functional significance, "centres," are limited in most cases by well known sulci. This observation is confirmed by Vint (1935) as the result of his finding that the cytoarchitectonic of the East African Negro's brain is similar to that of the European. We have elaborated the contour tracings of the Swazi brain and have mapped out standard areas of cortical localisation, as defined in the European brain by Elliot Smith (1907), Brodman (1907), Kappers (1921), von Economo and Koskinas (1935), using the sulcal patterns as a guide (figure 15). We have superimposed the area of probable injury on this tracing.

The following deductions can be made from this analysis:

(a) The lower anterior end of the lesion corresponds with the anterior half of Broca's centre of speech.

(b) The posterior third of the area frontalis anterior and practically the whole of the posterior half of the middle frontal area are included in the lesion. These areas, according to the recent analysis by von Economo and Koskinas represent the cortical centres of writing and of ocular movements. They also include portions of area 9 of Brodmann.

(c) The posterior part of the area frontalis superior, as well as a small portion of the intermediate portion of this area, are involved. These areas correspond to field 8 of Brodmann. *They are identified in figure 98 of von Economo and Koskinas' book as the cortical centre for erect posture, progression and head posture.*

(d) The upper portion of the anterior half of the precentral area (area 6 of Brodmann·and area 6 a.β. of Foerster) which also is affected, belongs to the preceding group of cortical centres of locomotion.

(e) The extensive part of the motor cortex (area 4) which is included in the traumatic lesion, according to von Economo and Koskinas is concerned in the control of the trunk, of the lower extremities and possibly also of the upper arms.

(f) Of the sensory cortex of the postcentral area (areas 1, 2 and 4 of Brodmann) only a small portion has been injured, but sufficient to involve the leg and foot centres according to von Economo and Koskinas' map. It is significant that the area of traumatization coincides, in its posterior projection with the backward extension of the sensory cortex into the superior parietal lobule just above the intraparietal sulcus. This zone has been repeatedly recognised as being concerned in the sensory projection of the hand and forearm, as well as in stereognosis. (Von Economo and Koskinas, Elliot Smith, Kappers).

Associated Arm Swinging Movements.

Why should there be an interference with the contralateral arm-swinging movements associated with walking, together with a support reaction of the homo-lateral arm, in a case of unilateral cortical injury of the premotor region of the cerebral cortex?

When we examined the patient with the specific object of recording his arm-swinging movements associated with walking, we discovered an impairment of the movements of the contralateral, i.e. *the right arm.* The support phenomenon had been observed on the *left arm.* This discovery immediately seemed to distinguish the nervous mechanism underlying the support reaction, which is always homolateral, from that responsible for the interference with the associated arm-swinging movements during walking. A careful analysis of the evidence presented by our case has, however, proved the contrary, namely, that both phenomena are fundamentally related.

Wartenberg (1939) has recently again drawn attention to the well known fact that disease of the cerebellar hemispheres frequently leads to interference with, or cessation of the pendular arm-swinging movements associated with walking. This sign has not yet been found in cases with lesions of the palaeocerebellar nuclei, while it has been observed in neo-cerebellar and neo-cortical lesions (Halpern. 1939).

This fact alone indicates that this symptom must be regarded as a release phenomenon, resulting from the disappearance of the restraining functional influence of lately evolved levels of the central nervous system.

Wartenberg maintains that absence of the associated arm-swinging movements during walking, if one-sided, may be regarded as a homo-lateral indicator of a pathological process in the cerebellar hemisphere; providing no extra-pyramidal or pyramidal lesions are present. This latter reservation must be made, for absence of arm-swinging movements during walking is also a common and early sign of extra-pyramidal and sometimes of pyramidal disease.

The writers have not discovered any statements in the literature as to the precise nature of the patho-physiological mechanism in cases of interference with the normal arm-swinging movements during walking. Physiologically, the movements represent a distinctive type of reflex action involving the alternating contraction and relaxation of opposed muscle groups. They are not mere passive pendulum swinging movements caused by the varying momentum of the arms. If the latter assumption were correct, the " flaccid " arm in cases of peripheral nerve lesions would also swing in a pendulum-like manner. This, however, is not the case. The absence of normal arm-swinging in cases of cerebellar and extra-pyramidal lesions, is also due to loss of the normal reflex mechanism which underlies the physiological action. The condition, however, may also be due to active interference with the physiological reflex mechanism.

In our case the unilateral absence of arm-swinging movements during walking is due to abnormal muscular reflex activity. This new muscular integration apparently represents a release phenomenon awakened by the traumatic elimination of the physiolgical activity of the contra-lateral premotor cortical area. Essentially identical abnormal reflexes, initiated in apparently the same manner, but manifesting themselves on the ipsi-lateral side, are responsible for the appearance of the support reaction.

THE RELATIONSHIP BETWEEN THE SUPPORT REACTION AND THE ASSOCIATED ARM SWINGING MOVEMENTS DURING WALKING.

The evidence afforded by our case indicates that the injured parts of the middle frontal and of the posterior part of the superior frontal areas are intimately concerned in the production of the transient homolateral proprioceptive support reaction, as well as with the loss of the associated swinging movements of the contralateral arm during walking.

These two signs are closely associated. Both have appeared in our case as results of the traumatic disturbance of the highly differentiated reflex mechanism, which controls mass movements, tonus and posture of the extremities in the adult human. This mechanism operates through nervous structures which are distributed throughout the central nervous system, but more especially through the cerebellum and through the cerebral cortex.

That the support phenomenon and loss of arm-swinging during walking can result from lesions of the cerebrum, as well as from lesions of the cerebellum, has been repeatedly demonstrated. However, our case is the first instance of these two signs appearing together. Its significance is enhanced by the fact that strict localisation of the causative disturbance is possible. The lesion affects the pre-motor cortical area.

A FUNCTIONAL EQUIVALENT OF QUADRUPEDAL PROGRESSION.

The functional co-operation between cerebellum and cerebrum has been the subject of considerable discussion recently. More and more evidence is accumulating to demonstrate the precise nature of nervous integration of those two structures. Cerebello-cerebral co-operation is essential for normal locomotion. The cerebellum controls and influences all automatic, continued, reflex movements which originate in the cerebrum. In walking, the associated arm swinging movement is such an automatic, stereotyped activity (Fulton, 1938).

The study of our case indicates that arm-swinging during walking is, from the point of view of evolution, not a recently acquired motor function for which special nervous structures were evolved in the cerebellum. *The associated arm swinging movements during walking are the remains of the fore-limb movements in quadrupedal progression.* Haller (1940) has recently succeeded in demonstrating a quadrupedal progression centre in the subthalamus.

LOCALISATION OF LESIONS PRODUCING SUPPORT REACTION.

The support reaction can result from lesions of even such ancient structures as the palaeo-cerebellum. (Dusser de Barenne, 1937). Loss of arm-swinging movements in walking, a sign which, naturally, can be found in man only, is always due to lesions either of the pyramidal or extrapyramidal tracts, unless it is caused by lesions affecting the cerebellar hemispheres (Wartenberg), or the frontal lobes (Halpern). In other words, lesions responsible for the loss of arm-swinging have so far been found only in cases of injury to phylogenetically more recently developed elements of the human brain. This sign appears in man only because he alone holds the upper extremities in a dependent position during erect walking. Other mammals, with a few exceptions, if made to stand erect on their posterior extremities, elevate the anterior extremities to approximately the horizontal position. In anthropoids there is, in addition to the horizontal elevation, a slight flexion at the elbows (Brain, 1927). This is also the posture of the upper extremity in the child during the early phases of walking.

In mature man a special postural mechanism counteracts this tendency of the upper extremities to be extended at the shoulders and flexed at the elbows. This latter mechanism is frequently disturbed in the spastic phase of cerebral hemiplegia (Brain).

This postural adjustment develops in the child at the time when the infant has learned to stand erect. Balduzzi stated that at that time a support reaction can be elicited. We have tried to corroborate this statement, but have failed to discover a single case of support reaction among 22 children of between 3 and 6 months of age. The "normal" dependent position of the upper extremity in man involves relaxation of the anti-gravity muscles. Nevertheless, the pendular co-movements of the arm during walking remain, being vestiges of the ancient quadrupedal mechanism of locomotion. This theory explains the simultaneous occurrence in man of the support reaction and of loss of arm-swinging in walking as the result of a single cerebral lesion.

What is not yet immediately evident, however, is why the support reaction should always be homolateral, whereas the loss of arm-swinging in walking, if of cerebral origin, is contra-lateral (Halpern), as in the case of our patient.

The support reaction has been found in association with lesions of practically all extra-pyramidal motor elements of the central nervous system. The localisation of the lesion in our case is, therefore, typical. *It affects a bilateral cortical control area which supervises erect posture and progression.*

THE CENTRAL NERVOUS MECHANISM AND EVIDENCE CONCERNING THE LOCALISATION OF THE CEREBRAL CENTRE INVOLVED IN THE CONTROL OF THE SUPPORT REACTION.

In our case the support reaction must be interpreted as a reflex phenomenon allied to the traumatic mechanism which simultaneously has led to the suppression of the arm-swinging movement. In Bucy and Fulton's experiments on apes similarly contrasted bilateral postural reflex responses were obtained by stimulation of a specified centre located in areas 4 and 6. It appears that a homologous centre has been interfered with in our case. This centre, it would seem, once had the specific task of controlling quadrupedal progression.

In his classical lecture demonstration before the First International Medical Congress in London in 1881, Goltz drew attention to disturbances of quadrupedal co-ordination in walking in de-corticised dogs. He emphasised that the symptom of dys-co-ordination occurs without paralysis being present, and that it is permanent. Judged by present day standards of neurological research, Goltz's methods of operating on the cerebral cortex were crude. Thus, although his findings are still to-day of significance, his material cannot be utilised for the exact localisation of cortical control centres of quadrupedal progression.

Fifty years later, Buytendijk (1931-1932) again was impressed by the observation that lesions to the cerebral cortex of the rat affect the co-ordination of their walking movements while not producing paralysis. The inco-ordination became obvious when the animal were required to run on narrow pathways or to jump. The disability thus produced was permanent. Maier (1932, a, b), corroborating the older findings, stated that the disturbance is associated with cortical lesions in the anterior half of the brain. In a later paper Maier (1935) was able to designate a symmetrical cortical area in the cerebral cortex of the rat, destruction of which invariably produced marked motor inco-ordination in walking. This area (*X*) which is shown in figure 17, constitutes about five per cent. of the total cortical surface. It includes parts of Fortuyn's somasthetic area " J " and parts of the motor areas " F " and " N."

Judging by the results obtained by Bucy and Fulton (1933) in ablation experiments on areas 6 and 4 of the motor cortex in baboons, area Y of figure 17 may be homologised with Maier's co-ordination centre.

It appears permissible to surmise that a cerebral centre in the human brain, functionally corresponding to these areas, is released by the cortical injury, which in our case has led to the appearance of the support reaction. We assume that in the human brain, the area (*Z*) corresponding to Maier's co-ordinating field for quadrupedal walking is roughly that shown in figure 17. The relationship of this area to motor and pre-motor cortex is one which requires further study.

In cases of experimental removal of the cerebral hemisphere, Rademaker (1937) records bilateral support reaction. The simultaneous appearance of the support reaction and of loss of arm-swinging movement in walking can be satisfactorily accounted for by postulating interference with a specific quadrupedal locomotion control area in the premotor cortex.

In human beings the support reaction proper can usually be elicited by proprioceptive stimuli (Stenvers). The exteroceptive (magnet) reaction is much less commonly observed. The exteroceptive and the proprioceptive pathways which are involved in the support reaction, end in various parts of the contralateral cerebral cortex and in the homolateral cerebellar hemisphere respectively. From here (figures 16, 18a and 18b) the reflex arc is completed in relays via the frontal, temporal and parietal cortical fields to homolateral motor discharge centres situated in the corpus striatum, cerebellum, and mesencephalon and the pons. (Brücke). The activities of the latter centres are influenced by the cortices which are referred to (Balduzzi). Our case has finally shown that the centre in the pre-motor field (6aβ) in its turn controls these latter cortices(figure 18a). The support reaction appears with lesions which

(a) Modify the restraining influence of the temporal, frontal and parietal cortices;
(b) Stimulate special motor discharge centres or the tracts leading from these;
(c) Render sensory centres hypersensitive.

Our case has also shown that elimination of the final control from the erect posture and progression centre in area 6aβ of the pre-motor cortex (figure 19) would produce a support reaction directly. It is also in that case associated with the appearance of the sign of loss of arm swinging.

In most cases of support reaction, lesions were found in the cerebellum, frontal lobes, temporal lobes and internal capsule, in the above order of frequency. Very rarely it may be associated with pontine and spinal lesions (figure 19). Stenvers found that all described cases have so far followed diffuse rather than circumscribed lesions. Our case is, therefore, outstanding as the reaction was provoked by a circumscribed lesion in the pre-motor cortex. Only v. Santha (1938) has recorded a similar case concerning a patient from whom Professor Penfield had excised practically the entire pre-motor cortical area 6aβ (figure 20). This corresponds with the location of cerebral injury in our case. Three days after the operation, v. Santha found a positive support reaction on the homolateral leg as well as fanning of the toes. He does not state whether a defect of the arm-swinging movements in walking was present.

SUMMARY.

The support reaction is described and its phylogenetic, physiological and clinical significance discussed. A case is presented in which the above phenomenon appeared subsequent to a localised injury of the pre-motor cortex. As the

support reaction was observed together with loss of arm-swinging movements on the contra-lateral side during walking, the nervous integration of the two involved processes was analysed. Our own as well as other examinations of normal and of diseased individuals suggest that a relationship exists between the above two reactions. They seem to have their origin in the relics of the central nervous representation of quadrupedal progression, which phylogenetically has preceded the bi-pedal mechanism of walking. In the course of development of this latest mechanism of progression, new motor centres have been evolved in the cerebral cortex which selectively dominate the more ancient nervous representation of the quadrupedal walk. Elimination of these recent cortical structures releases the ancient mechanism of which the support reaction, as well as the disturbance of arm-swinging during walking are representative elements. Our investigation suggests that these phylogenetically recent control areas for walking are situated in a circumscribed cortical territory closely corresponding with area 6aβ.

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TEXT TO ILLUSTRATIONS.

Figures

1A—De-cerebellate dog held in the air. The hindlegs are slightly flexed.

1B—Slight pressure applied to the soles of the paws leads to a powerful extensor thrust of the extremities.

2A—De-cerebellate dog lying on its back. The legs are flexed.

2B—A slight touch applied to the soles of the paws elicits a powerful extensor thrust. This is the so-called magnet reaction.
(The above are redrawn after Magnus and Rademaker.)

3—Diagram showing the main neurological findings in our case.

4—The operation scar on the head of the patient.

5—Röntgenograms of the head showing the extent and localisation of the trepanation opening in the skull in the lateral and anteroposterior views respectively.

Control examination for the support reaction. Right (normal) upper extremity.

6A—With the arm extended at the elbow joint full flexion at wrist joint does not produce forcible flexion of the arm. (Test for kinetic component of negative support reaction.)

6B—With the arm extended at the elbow joint, hyper-extension at the wrist does not transform the arm into a rigid pillar, and passive flexion at the elbow joint is still possible. (Test for static component of positive support reaction.)

6C—With the arm flexed at the elbow joint passive hyper-extension at the wrist does not lead to a forcible extensor thrust of the arm. (Test for kinetic component of positive support reaction.)

The support reaction. Left (affected) upper extremity.

7A—*The kinetic phase of the negative support reaction.* With the arm fully extended passive flexion at the wrist joint leads to forcible flexion of the whole extremity.

7B and C—*The kinetic phase of the positive support reaction.* With the arm fully flexed, passive hyper-extension at the wrist joint leads to a forcible extensor thrust of the whole upper extremity.

7D—*The static phase of the positive support reaction.* With the arm fully extended, passive hyper-extension at the wrist joint transforms the upper extremity into a rigid pillar. Flexion at the elbow is now impossible unless the extension at the wrist is released.

The technique of examining for a support reaction in the case of the lower extremity.

8A—Normally passive dorsi-flexion at the ankle joint does not produce forcible flexion at hip and knee joints. However, when a support reaction is present, a compulsory mass flexor movement follows flexion at the ankle joint. (*Kinetic component of the negative support reaction.*) While passive dorsi-flexion at the ankle joint is maintained the lower extremity remains rigidly flexed. (*Static component of the negative support reaction.*) On extension of the foot at the ankle joint, the flexor spasm ceases.

8B—Normally plantar-flexion of the foot at the ankle joint does not transform the leg into a rigid pillar. If a support reaction is present, plantar-flexion of the ankle joint produces a powerful extensor thrust of the leg. (*Kinetic component of the positive support reaction.*) The leg will now be rigidly kept in extension as long as passive plantar-flexion of the foot at the ankle joint is maintained. (*Static component of the positive support reaction.*) Release from this position is only possible by passive dorsi-flexion at the ankle joint.

Action currents of the triceps and biceps muscles in patients with support reaction of the upper extremity. (Redrawn after Altenburger, 1937.)

9—1, A—*Kinetic phase of the positive support reaction.* Only the triceps muscle contracts while the biceps muscle is relaxed.

9—1, B—*Static component of the positive support reaction.* An attempt to flex the rigidly extended limb passively provokes powerful contraction of the triceps muscle. The biceps muscle remains relaxed.

9—2, A—*Kinetic phase of the negative support reaction.* Only the biceps muscle contracts while the triceps muscle remains relaxed.

9—2, B—*Static phase of the negative support reaction.* An attempt to extend the rigidly flexed arm provokes powerful contraction of the biceps muscle. The triceps muscle remains inactive.
These electro-myographic records indicate that the phases of the support reaction are due to either pure flexor or pure extensor contractions, i.e. that they are not produced by the simultaneous action of agonistic and antagonistic muscle groups.

10—The patient shows loss of arm swinging on the right side during walking. During the phase of circumduction of the normally swinging arm, it appears as if the affected arm is longer than the normal one. This, however, is an illusion.

11—A graphical representation of the relative velocity of the forward swinging movements of the arms during walking.

12—The relative velocity of the backward swinging movements of the arms during walking (From an analysis of a cinematographic film.)

13—A contour tracing of the patient's skull indicating the extent of the injury. Chiene's lines and the surface markings of the areas of cortical localisation corresponding to these have been superimposed.

14—A contour tracing of a Swazi brain superimposed on the skull contour of the patient. Chiene's lines and the traumatic lesion have been superimposed.

15—Schematic representation of cortical localisation in the Swazi brain. The extent of the original injury is indicated in relation to these cortical areas.

16—The cortical areas of origin of the cortico-ponto-cerebellar tracts.

17—Cortical fields in brain of rat, baboon and man, injury to which caused profound disturbance of co-ordinated locomotion.

18a—The relationship between the locomotion centre in areas 6 aβ and the cortical motor fields from which the cortico-ponto-cerebellar tracts originate.

18b—Tracts which lead to the motor discharge centres of the basal-ganglia and the brainstem.

19—Lesions which, by irritation or paralysis of cell formations or tracts, may produce a support reaction.

20—A comparison of the localisation of the circumscribed cortical lesion responsible for the release of a support reaction in a case described by von Santha (1938), and that of the present investigation.

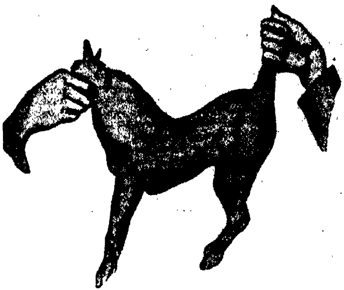


Fig. 1A.

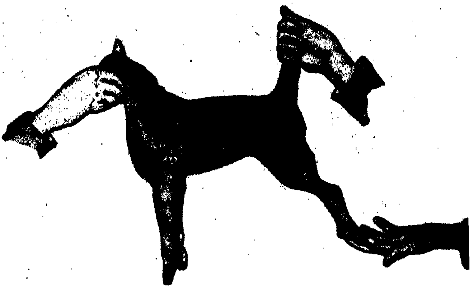


Fig. 1B.

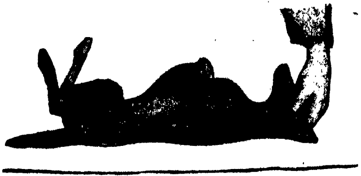


Fig. 2A.

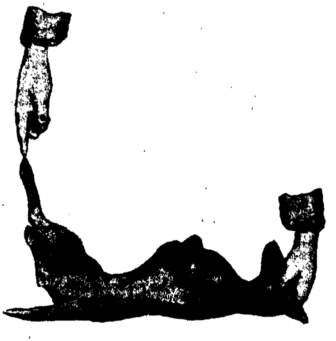
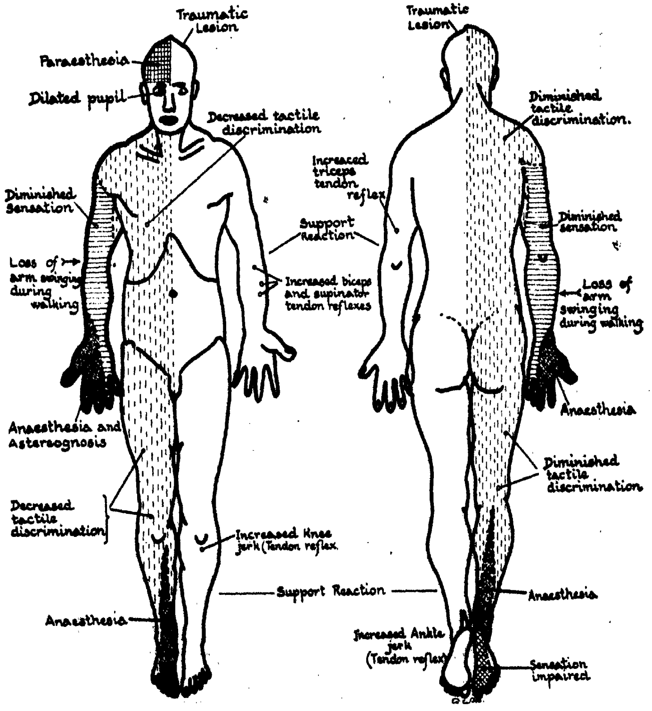


Fig. 2B.



Traumatic Lesion
Paraesthesia
Dilated pupil
Decreased tactile discrimination
Diminished Sensation
Loss of arm swinging during walking
Support Reaction
Increased biceps and supinator tendon reflexes
Anaesthesia and Astereognosis
Decreased tactile discrimination
Increased Knee jerk (Tendon reflex.
Support Reaction
Anaesthesia
Traumatic Lesion
Diminished tactile discrimination.
Increased triceps tendon reflex
Diminished sensation
Loss of arm swinging during walking
Anaesthesia
Diminished tactile discrimination
Anaesthesia
Increased Ankle jerk (Tendon reflex)
Sensation impaired

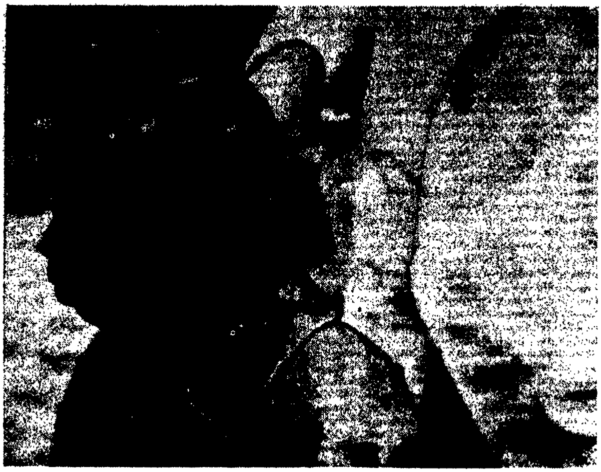


Fig. 4.

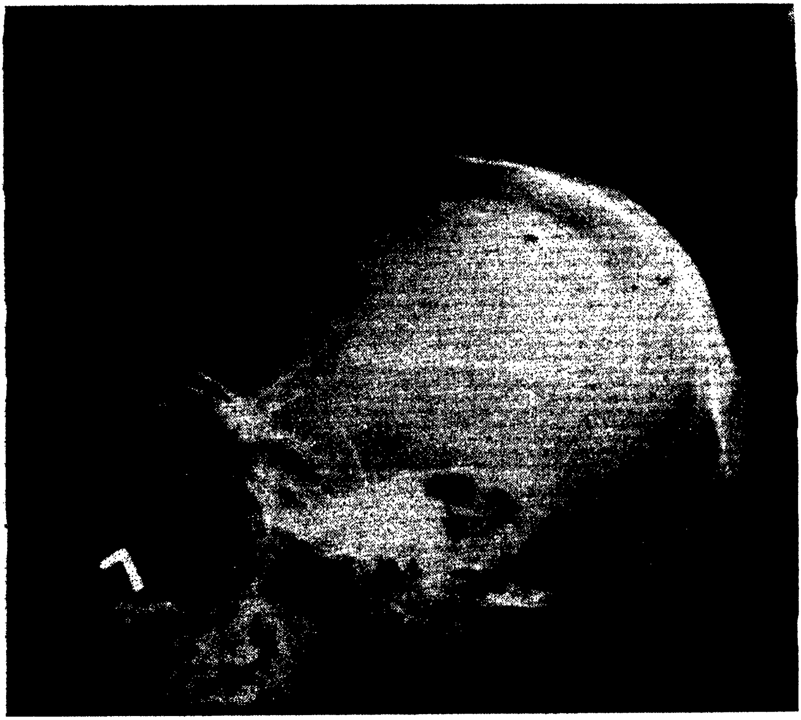


Fig. 5A.

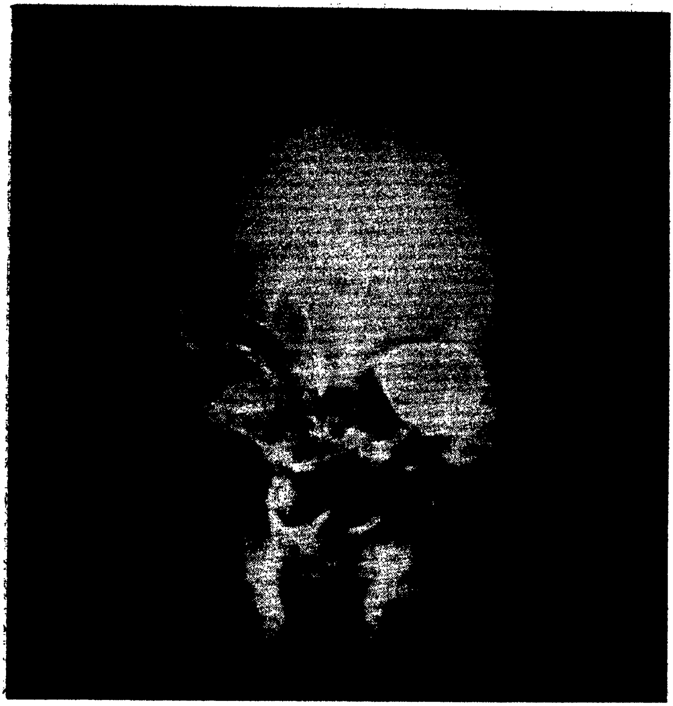


Fig. 5B.

Fig. 6 (a)

Fig. 6 (b)

Fig. 7 (a)

Fig. 7 (b)

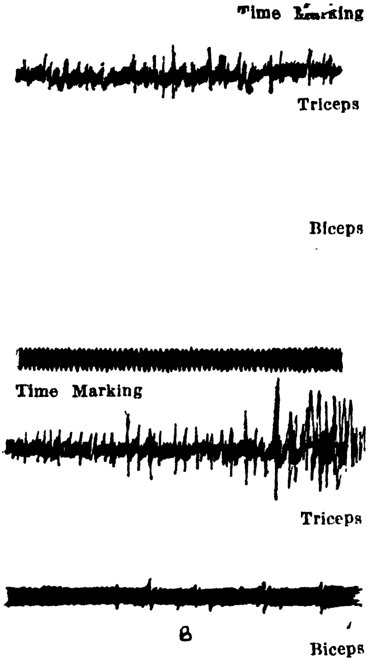
Fig. 7 (c)

Fig. 7 (d)

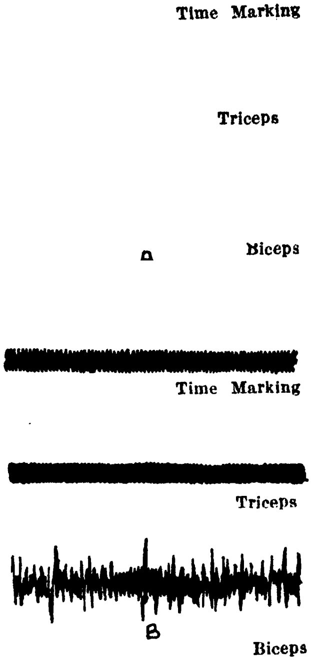
Fig. 8 (b)

Fig. 8 (a)

POSITIVE SUPPORT REACTION. Fig 9 (1)



NEGATIVE SUPPORT REACTION. Fig. 9 (2)



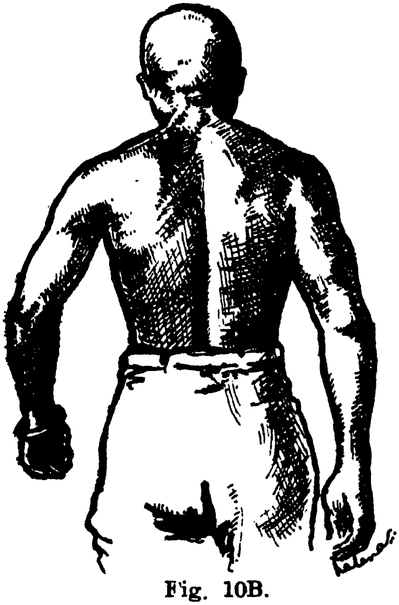


Fig. 10B.

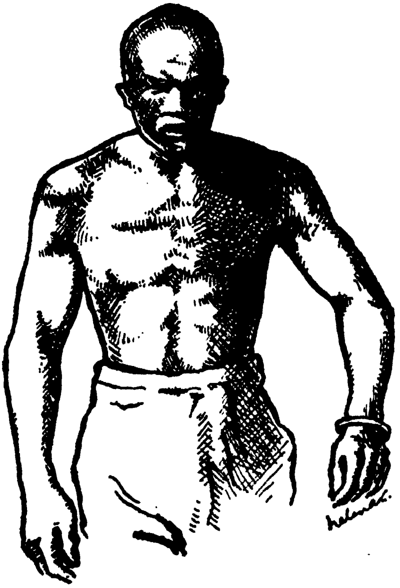
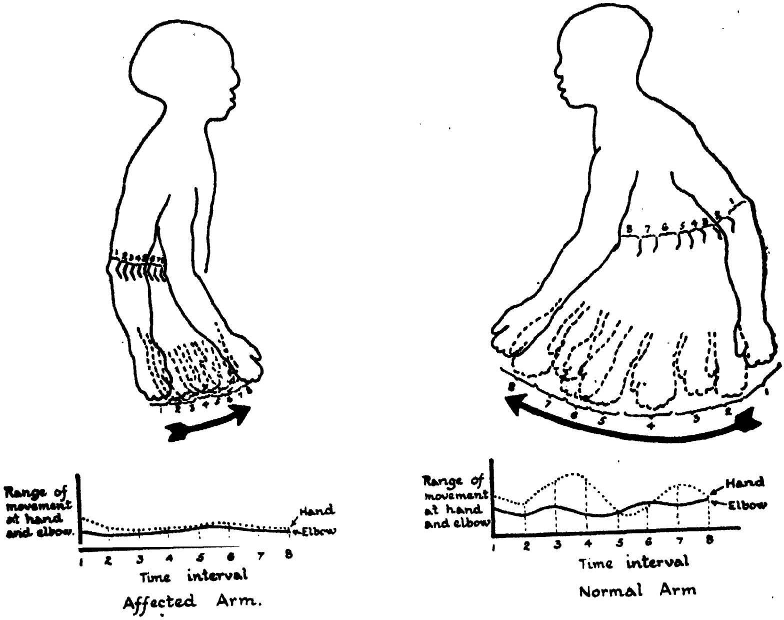


Fig. 10A.

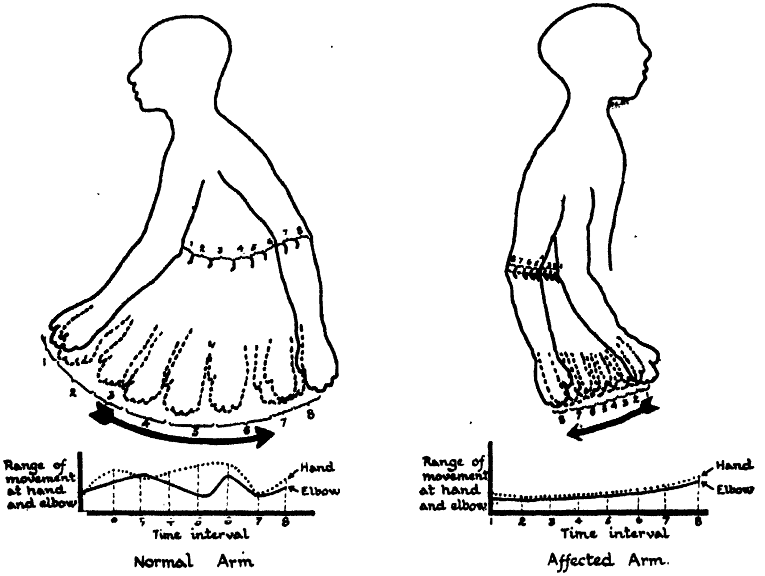


Affected Arm.

Normal Arm

Relative Velocity of Forward Swinging Movement of the arm during walking.

Fig. 11.

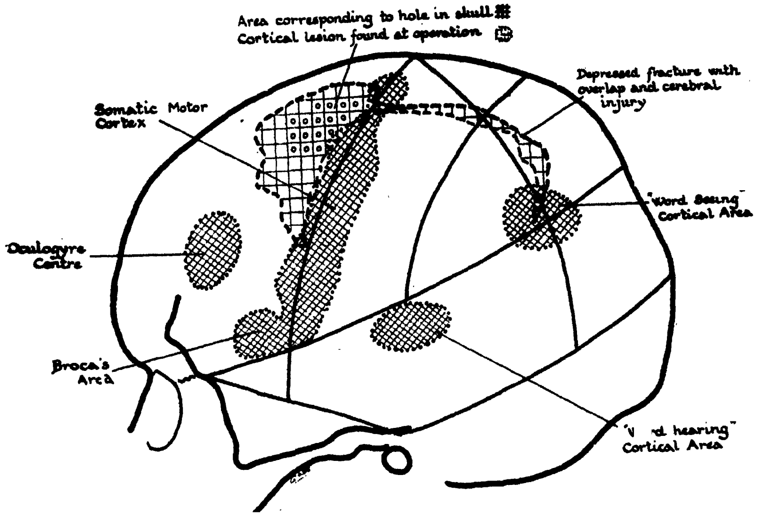


Normal Arm

Affected Arm.

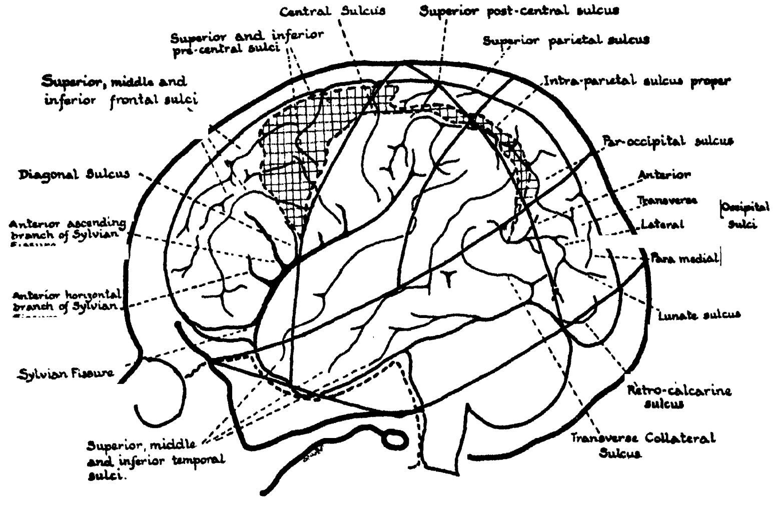
Relative Velocity of Backward Swinging Movement of the arm during walking.

Fig. 12.


Area corresponding to hole in skull ▦
Cortical lesion found at operation ⊞
Somatic Motor Cortex
Depressed fracture with overlap and cerebral injury
Oculogyre Centre
"Word Seeing" Cortical Area
Broca's Area
"Word hearing" Cortical Area

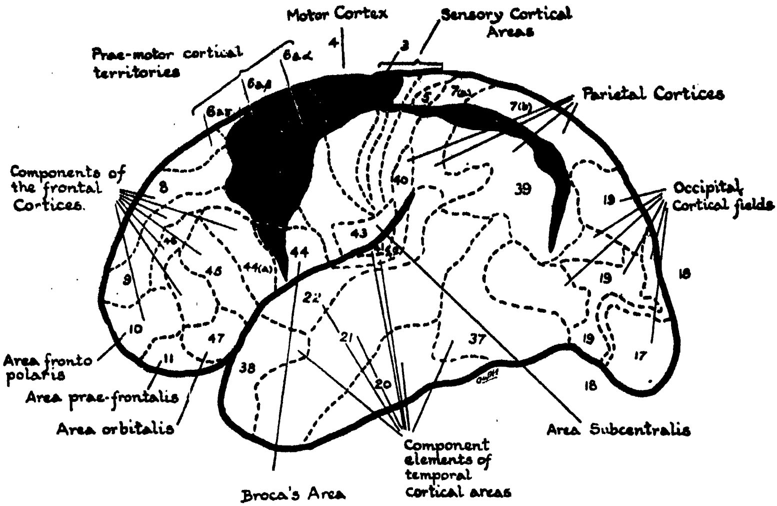
Contour Tracing of Skull of Patient with extent of injury, Chiene's Lines and surface markings of areas of cortical localization.

Fig. 13.


Central Sulcus
Superior post-central sulcus
Superior and inferior pre-central sulci
Superior parietal sulcus
Superior, middle and inferior frontal sulci
Intra-parietal sulcus proper
Par-occipital sulcus
Diagonal Sulcus
Anterior
Transverse
Lateral
Para medial
Occipital Sulci
Anterior ascending branch of Sylvian Fissure
Anterior horizontal branch of Sylvian Fissure
Lunate sulcus
Sylvian Fissure
Retro-calcarine sulcus
Superior, middle and inferior temporal sulci.
Transverse Collateral Sulcus

Swazi Brain and Skull Contour.
Chiene's Lines and Traumatic Lesion superimposed.

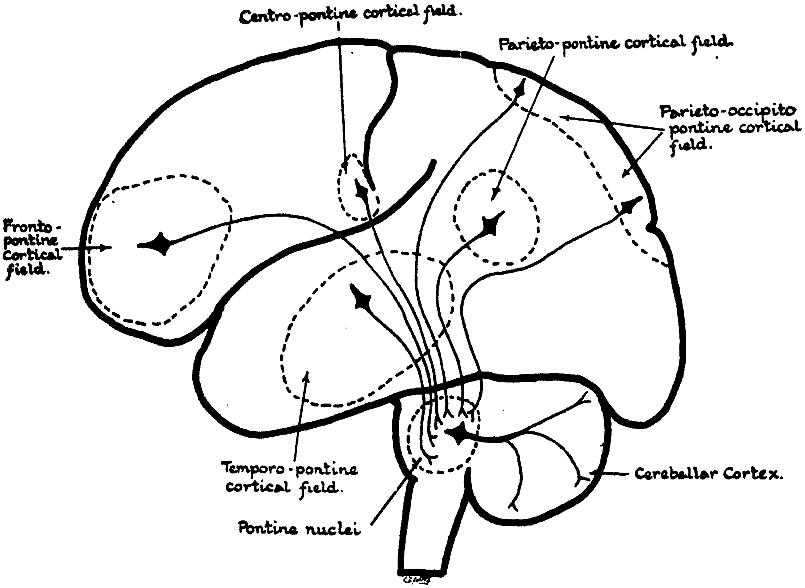
Fig. 14.



Swazi Brain with Cortical Localization

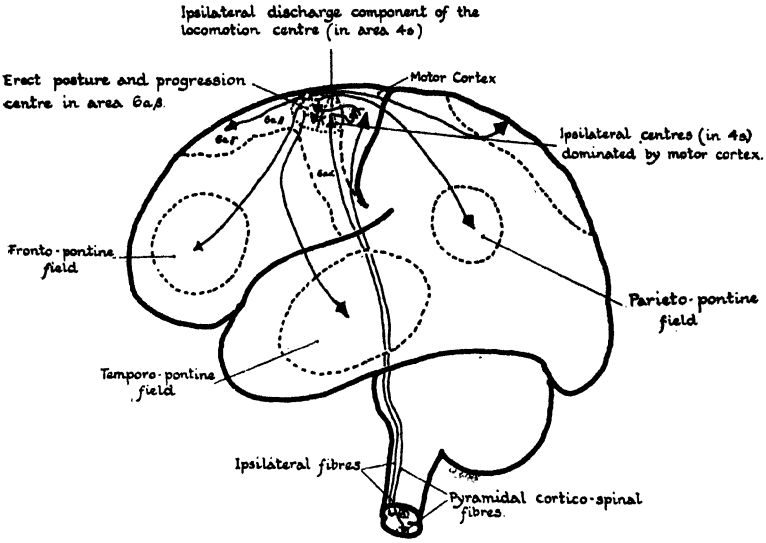
Extent of original injury indicated by shaded area

Fig. 15.


Centro-pontine cortical field.
Parieto-pontine cortical field.
Parieto-occipito pontine cortical field.
Fronto-pontine Cortical field.
Temporo-pontine cortical field.
Pontine nuclei
Cerebellar Cortex.

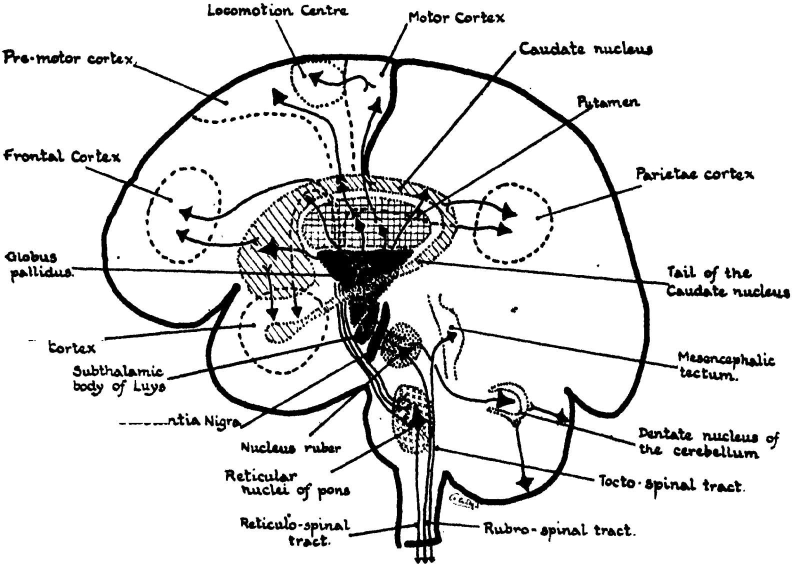
Cortico-ponto-cerebellar Connections.

Fig. 16.


Ipsilateral discharge component of the locomotion centre (in area 4s)
Erect posture and progression centre in area 6aβ.
Motor Cortex
6aβ
6aγ
6aα
Ipsilateral centres (in 4s) dominated by motor cortex.
Fronto-pontine field
Parieto-pontine field
Temporo-pontine field
Ipsilateral fibres
Pyramidal cortico-spinal fibres.

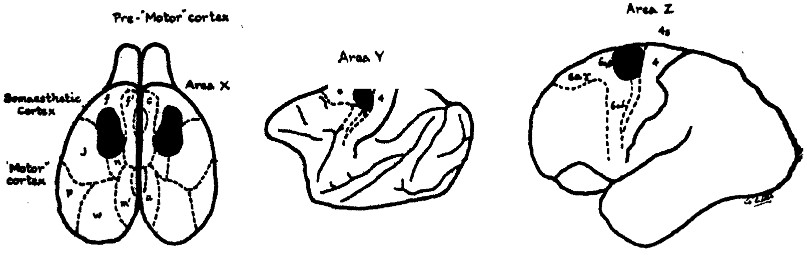
Relationship between locomotion centre in Area 6aβ and cortical motor fields from which the cortico-ponto-cerebellar tracts originate.

Fig. 18a.



Tracts leading to motor discharge centres of the basal ganglia and brainstem.

Fig. 18b.

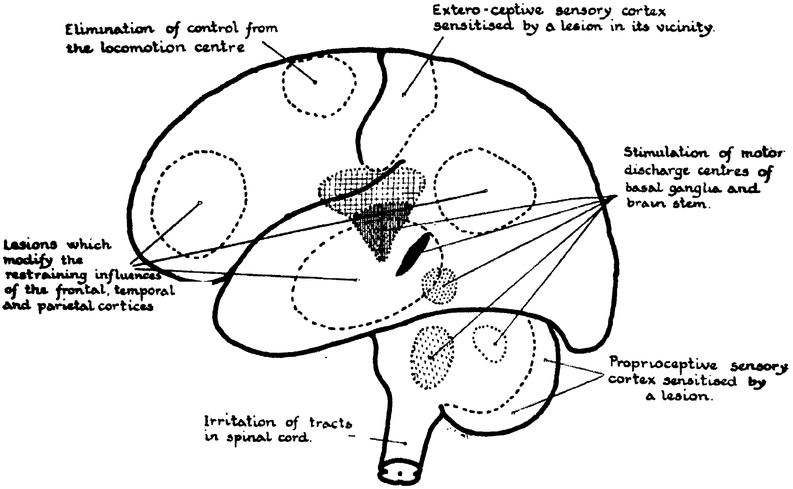


Rat
(Maier, 1935)
Destruction of the area "X" leads to loss of co-ordination of movements concerned in walking.

Baboon
(Bucy and Fulton, 1933)
Electrical stimulation of area "Y" results in ipsi-lateral and contra-lateral motor responses. The former are enhanced by eliminating the control from area 4

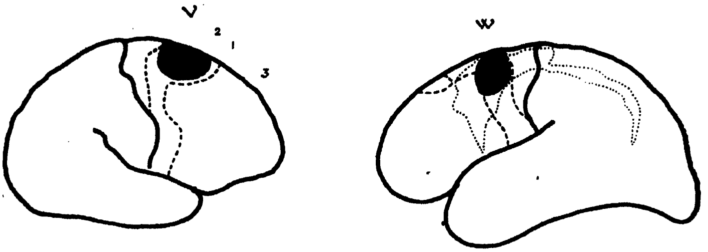
Man.
(Present Case.)
Traumatic lesion to area "Z" is followed by support reaction the homo-lateral side and of arm swinging on the side during walking.

Fig. 17.


Elimination of control from the locomotion centre
Extero-ceptive sensory cortex sensitised by a lesion in its vicinity.
Stimulation of motor discharge centres of basal ganglia and brain stem.
Lesions which modify the restraining influences of the frontal, temporal and parietal cortices
Proprioceptive sensory cortex sensitised by a lesion.
Irritation of tracts in spinal cord.

Lesions which may elicit the Support reacti

Fig. 19.



Case I, V. Santha.
Excision of area "V" resulted in transitory paralysis, increased Leri-reflexes on the contra-lateral side, support reaction of the lower extremity and fanning of the toes.

Case II, Jokl and Schepers.
Injury to area "W" resulted in homo-lateral support reaction and contra-lateral disturbance of associated arm swinging movements during walking.

Fig. 20.

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MECHANISMS OF ATHLETIC INJURIES

BY

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Read 30th June, 1941.

Since the publication, in 1914, of G. von Saar's book " Die Sportverletzungen," a large volume of literature has accumulated dealing with surgical conditions encountered in athletes. Most investigators, however, have confined themselves to either presenting case histories, or to giving statistical analyses of clinical material. Little attention has been paid to the *mechanisms* of sport injuries. This is all the more surprising since it is this topic in particular which, more than any other aspect of athletic surgery, deserves to be subjected to a scientific analysis. Efficient prophylactic measures against accidents connected with physical exercise must be based on exact knowledge of the mechanisms of their occurrence. For this reason we have undertaken this study of a consecutive series of athletic accidents of our own observation, which gives consideration not only to the diagnostic, but also to the anamnestic as well as epicritic aspects of each case.

List of Injuries.

1. *Fracture of elbow through fall after vaulting.*

(a) Accident occurred while gymnast vaulted over long box. ('Through vault.') When landing behind the box he slipped, fell backward, and bumped his left elbow on the hard floor. X-ray examination revealed fracture of basis of olecranon.

(b) This injury is a typical one. However, it is avoidable.

i. The danger of a gymnast falling backward in situations of the kind described above, must be anticipated by the instructor. If he stands by in the prescribed way, he will be able to prevent recurrences of this type of accident.

ii. Rubber gymnasium mats must be placed *underneath and behind* the vaulting apparatus.

2. *Compound fracture of first and second toes through negligent handling of parallel bars.*

(a) Accident occurred after conclusion of gymnastic lesson while pupils were removing parallel bars. In the case of the standard steel base model, as is used in our gymnasia, this is done by elevating the apparatus by means of a special steel lever carriage which rests on wheels. The heavy appliance can thus be easily shifted.

When the lever carriage was subsequently removed, a student's foot was inadvertently placed under the steel basis of the parallel bars. A crush fracture of the first and second toes was the result.

(b) This injury may be regarded as typical. It is, of course, avoidable. In our department this accident has now been eliminated simply by explaining to instructors and students the mechanism of its occurrence.

3. *Tear of trapezoid ligament of ankle joint produced through athlete stepping accidentally into starting hole.*

(a) While walking off the running track at dusk, a girl athlete stepped accidentally into a starting hole, suffering a severe injury of the lateral ligament of the right foot with extensive haemorrhage.

(b) This is a typical mechanism of injury. It can be eliminated by instructing the students, as well as by replacing the customary track holes by starting blocks which should be painted white and thus be rendered conspicuous.

4. *Septic infection of palmar space caused by skin laceration through horizontal bar exercises.*

(a) While practising grand circles on the horizontal bar, a gymnast injured the skin of his palms. At first this injury was superficial and no notice was taken of it. Continuing with his exercises, a deep tear was produced in the left hand. Inflammation ensued resulting in severe septic infection involving palmar space and lower forearm. The condition had to be treated surgically, and patient was out of work for a considerable time.

(b) This is a frequent gymnasium injury which, in its initial stages, is usually neglected. Even in greatly experienced gymnasts, skin injuries in the palms occur in the course of exercises involving powerful centrifugal stress, like grand circles, especially those with changing of grip, where the entire body weight rotates around one hand. As a rule, the typical gymnastic skin injury of the palm does not originate suddenly. It is almost invariably the result of lack of care, an initial slight injury being subjected to further traumatisation through continuation of the exercises.

This condition can be eliminated through education. Horizontal bar exercises must be discontinued immediately the palmar skin is abraded or lacerated.

5. *Dislocation of sternal end of clavicle during parallel bar exercises.*

(a) Accident occurred while a gymnast, who without supervision, was swinging in cross-rest position on the parallel bars, fell back into folded rest position. At this stage he accidentally slipped through the bars and, making a strenuous effort to hold his grip, felt a sharp pain over the chest, and dropped to the ground. Clinical and X-ray examination revealed complete forward dislocation of sternal end of clavicle.

(b) If an experienced instructor had been in attendance, he might have been able to support the back of the gymnast when he fell. However, this is an unusual injury of the kind which one cannot expect to eliminate through education.

6. *Concussion through " heading " pushball.*

(a) While playing pushball for the first time in his life, an experienced gymnastic instructor foolishly tried to "head" the huge ball weighing 30 lbs. Jumping head first into the ball with full force, he flopped to the ground unconscious. Consciousness was regained after a few minutes whereafter he felt shaky, and complained of a severe pain in the neck. We thought, of course, of the possibility of a dislocation and/or fracture of the cervical spine being present. However, X-ray examination dispelled our fears in this respect.

(b) This injury was caused solely by the foolishness of the otherwise intelligent player who, in the heat of the game, lost his judgment.

7. *Fracture of radius and ulna during " stick relay."*

(a) In the course of a simple relay race whereby each member of the team has to jump over a stick held by two pupils, a boy of twelve years of age kicked one of his play partners against the lower arm. Although the impact did not appear severe, the result was a fracture of radius and ulna with considerable displacement.

(b) Subsequent investigation revealed that the patient had a particularly thin and under-developed skeleton. This abnormality must under the circumstances be considered the most important single factor responsible for the injury.

8. *Fracture of cervical spine during forward somersault.*

(a) During an attempt to perform a forward somersault, a gymnast landed with the vertex of his head on the ground. A sudden flexion occurred between his head, acting as a short lever, and the long lever represented by his trunk and legs. At this stage the athlete did not experience any discomfort. About ten minutes later, however, he complained of a feeling of stiffness in the neck as well as of pain in the back and along the sterno-mastoid muscles. Examination revealed stiffness and limitation of movements in the neck owing to extreme tenderness along the left sterno-mastoid muscle. There was also marked tenderness over C3, 4 and 5.

X-ray showed slight anterior compression of 5th cervical vertebra suggesting a crack fracture. There was no dislocation and no loss of alignment in the cervical spine. *X-ray pictures taken in the lateral direction conclusively proved the presence of a crack fracture of the body of C5 with compression.*

(b) An analysis of the mechanism of this accident reveals a combination of pathogenetic factors. The patient is eighteen years of age and of asthenic build (height 6 ft. and weight 170 lbs.). Clinical and X-ray examinations showed that his skeletal structure is extraordinarily delicate. The diameters of the bodies of his vertebrae are less than 2/3rds of the normal size.

The patient hit the floor with a sharp impact, instead of rolling forward smoothly. Thus, the long lever represented by the portion of his body between neck and feet, swung vertically downward instead of rotating forward. This situation involved an acute flexion movement around a vertex situated at about the 5th cervical vertebra. The force of this angular impact produced the fracture.

Accidents of this kind are unavoidable. The most important single factor responsible for this accident is the patient's pathologically weak skeletal structure, an abnormality which as a rule cannot be recognised easily. It can be assumed that a normal spine would not have been fractured under the same circumstances. In fact, one is often surprised that many routine accidents in the gymnasium do not produce serious spinal injuries.

9. *Dislocation of Shoulder.*

(a) While performing "backward dislocation" on the swinging rings, a young man dislocated his left shoulder.

This case is of special interest because it concerns a sportsman of outstanding physical prowess. Among his athletic achievements he represented Oxford as an oarsman. Three years prior to the present accident he had suffered a dislocation of the same shoulder while playing in the swimming bath. In the meantime he had no complaints whatsoever and took part in various gymnastic activities. On repeated occasions, he performed "dislocations" on the swinging rings without suffering any discomfort.

(b) This case, of course, suggests that the dispositional factor plays an essential role in dislocations of the shoulder joint, while even an extraordinary development of muscles, as present in this patient, is unable to act as a physiological plaster cast.

10. *Separation of epiphysis cristae anterior. inferior.*

(a) A boy of 15 years of age competed in a sprinting race in an untrained condition. While changing over from stepping into striding style, about 25 yards after the start, he experienced a shooting pain, first in the right then in the left leg. Unable to move, he had to be carried off the field.

There was extreme tenderness over a relatively broad area along the thighs extending upward towards both loins. The boy was unable to flex his hips actively, and felt a sharp pain if passive flexion was attempted. However, once flexion was achieved, he felt fairly comfortable. X-ray examination revealed separation of the epiphysis cristae anterior, inferior, dextra. Furthermore, "strain" of both psoas muscles was diagnosed.

(b) This interesting accident could, of course, not be foreseen. The fact that the boy had been untrained may have had a bearing upon the injury, since training improves capillarisation of all tissues involved in exercise. The bilateral psoas muscle injury is well explained in the light of the analysis of muscle strain in athletes given by Jokl and Guttmann in 1933. (See also C. L. Lowman. J. Health and Physical Education, U.S.A., Sept. 1941, p. 398.)

11. *Fracture of nose sustained through falling forward after tumbling exercise.*

(a) While practising a knee-balance, a gymnast was unable to recover his standing position after being thrown back but fell forward flat on his face and fractured his nose.

(b) The mechanism of this accident is a typical one. Experienced tumbling instructors know that practically every beginner has difficulties in resuming the standing position after rotatory movements. It is easy to take precautionary measures, i.e., to provide for support in anticipation of the gymnast falling forward.

12. *Death in the boxing ring due to intracranial haemorrhage.*

(a) An amateur boxer received a blow to the chin which rendered him instantaneously unconscious. Falling backward, he hit the floor with the back of his head, suffering a fracture of the occipital bone. An arterial branch across the fracture line was ruptured and a fatal intracranial haemorrhage ensued.

(b) Severe injuries in the boxing ring will continue to occur as long as boxing is considered a suitable branch of physical education. In boxing, injuries are deliberately produced, and even scientifically planned. There is only one way of eliminating boxing injuries, and that is to eliminate boxing.

13. *Severe sepsis following insignificant cutaneous injury.*

(a) After playing fistball for one hour in the morning, a gymnastic instructress noticed a blood blister of the size of a lentil over the base of the left thumb. At lunch time thumb and lateral parts of hand and wrist were painful. During the early hours of the afternoon several tender red streaks could be seen and felt to extend from the blister over lower arm, elbow and medial aspect of upper arm towards the axilla. During the ensuing night the infection affected the axillary glands which became swollen and very painful. Early in the morning rigors occurred, indicating general infection. Cultures from the original blister revealed haemolytic streptococci. The patient was admitted to hospital. Local treatment of the site of entrance of the infection as well as massive doses of proseptasine averted the threatening catastrophe. Patient made a full recovery.

(b) This case does not represent a typical history. It is the rule rather than the exception that cutaneous injuries in athletes remain aseptic.

A careful clinical analysis was carried out to explain why the immunological resistance of this patient was so low as to allow a malignant sepsis to follow within a few hours an insignificant closed injury. The following pathogenetic factors were ascertained.

1. The presence, presumably over a period of several months, of a taenia saginata.
2. An incompletely healed ulcer originally caused by an insect bite on the right heel which had been present for several weeks.
3. Chronically inflamed tonsils and a history of frequent streptococcal throats. (Several bacteriological tests were made.)

The fact that none of these conditions which can, of course, be easily dealt with, had ever fully incapacitated the patient explains why such a profound deterioration of the immunological resistance of the patient could develop gradually. The physiological strain of an hour's exercise, together with the slight cutaneous injury, caused the final breakdown.

The moral to be drawn from this case history is that infections of every description, local or otherwise, must always be taken seriously. They must be attended to whenever possible, whether they cause acute clinical symptoms or not.

DISCUSSION.

In the above series of case histories of athletic accidents the study of the mechanisms of the traumata reveals that in the majority of instances the injury could have been avoided. It appears that the most important factors involved in athletic injuries are lack of supervision, and deficiencies in the arrangement of equipment. There are, of course, other factors involved such as the choice of unsuitable sports, for example, in the case of boxing.

We are of the opinion that further studies of athletic injury mechanisms are most desirable. However, it must not be forgotten that the results of such studies must be brought to the notice of gymnastic teachers who cannot be expected to follow the medical literature. Thus with regard to the way of presenting such studies as well as in respect of the choice of the medium of publication this point must be kept in mind.

We venture to say that close collaboration between the sports doctor and the physical education teacher is able to reduce, within a short period, the number of athletic accidents to a bare minimum. Among the numerous medical tasks revealed in connection with physical education during recent years that of systematically reducing the rate of athletic injuries is one of the most important and certainly one of the most interesting.

SUMMARY.

A number of case histories of athletic accidents is presented in which the mechanism of the trauma has been subjected to a critical analysis. It can be seen that most athletic accidents are avoidable. A plea is made to bring the results of investigations of the kind presented in this paper to the knowledge of physical training instructors who are the only group of persons capable of utilising, in practice, the knowledge gained in a clinical analysis of the problem.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XXXVIII, pp. 267-277. January, 1942.*

PHYSICAL EFFICIENCY AND PULMONARY TUBERCULOSIS

BY

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Read 30th June, 1941.

Symptoms and physical signs of pulmonary tuberculosis appear as a rule only when the disease is well established. Similarly, tubercle bacilli are present in the sputum mostly only when the lesion is fairly extensive. In probably 80-90% of cases the condition is well advanced before any clinical symptoms appear. Too much reliance, therefore, cannot be placed on anamnesis or clinical signs and on the demonstration of tubercle bacilli in the sputum, if an attempt is made to discover the disease at an early stage. Tuberculosis must be sought and found among healthy looking people if cases are to be treated most successfully, i.e., if the patient's physical, social and economic efficiency should be assured. To achieve this aim, the disease must be kept from becoming " open " or communicable.

In emphasising the importance of studying fluctuations and deterioration of physical efficiency with a view to discovering early tuberculosis in young individuals, we wish to stress the frequency with which the disease occurs in persons with a high or even extraordinary standard of muscular working power. In 1936, R. Rimini, in a paper " La tuberculosi polmonare negli atleti," described twenty cases of well known athletes breaking down with pulmonary tuberculosis. Brady and Kahn (1937) and Fitz (1939) communicated interesting cases of robust athletes collapsing after a violent exertion with haemoptysis of pulmonary tuberculous origin. Young and Faber (1940) described eight case histories to show that "tubercle bacilli have very little respect for athletic ability."

It can now be taken for granted that even outstanding athletic efficiency is no safeguard against tuberculosis, and that it is a fallacy to regard tuberculosis as a disease of the weak, the malnourished and the under-privileged only.

Of clinical significance for the discovery of early tuberculosis, it is not the standard of physical efficiency but its fluctuations and deterioration, observations of which are of great anamnestic significance.

If this were done, many cases of pulmonary tuberculosis which to-day pass unnoticed, would be diagnosed at an early stage. We shall present clinical evidence to the effect that active tuberculosis is one of the diseases which *always* causes marked deterioration of physical efficiency. If a patient reports that his physical efficiency has recently deteriorated, the possibility of tuberculosis being present should always be considered. It is peculiar that practitioners readily associate a decrease of physical efficiency with heart disease. However, such cases are rare, at least in young individuals. Even in cases of single or combined valvular lesions, of congenital defects or of rheumatic fever causing permanent damage of the heart, a decrease of physical efficiency does not necessarily occur. (Jokl and Parade (1933), Jokl and Suzman (1940), Jokl and Melzer (1940), Cluver and Jokl (1941)). *In pulmonary tuberculosis, however, deterioration of physical efficiency inevitably occurs.* It might be an early or even the first symptom of which the patient becomes aware; only rarely it might manifest itself at a late stage when the disease has already advanced beyond help.

From our own experience we can state that many cases of tuberculosis are missed throughout the country every year in physicians' offices, in clinics and in hospitals and that many more tuberculous patients go through life physically weak, hampered in their work, but unconscious of their illness. Physical examinations frequently fail to reveal the disease, as active tuberculosis often causes very few or no clinical signs. The latter experience serves to emphasise the necessity of searching for new anamnestic criteria, such as the standard of physical efficiency on which we are laying emphasis.

It appears to us that the relationship between tuberculosis and physical efficiency ought to be studied with greater care. Exact knowledge of this problem will be of practical significance for the early diagnosis of the disease; for the assessment of the effects of various therapeutic measures; for prognostic purposes; and last but not least, with a view to the economic implications of tuberculosis for the individual as well as for the State.

ILLUSTRATIVE CASES.

CASE 1.—*J.E., European Male, Age 24 years, Pupil Pilot.*

For a period of six months, Mr. J.E.E., 24 years old, single, underwent a rigid athletic training course in order to prepare himself for service in the Air Force. He ran a distance of two miles daily, participated in rugby practice and took part in one competitive game of football every week-end. In addition, he played much tennis and excelled in tournaments. August 1, 1940, was the date on which he had to present himself to the recruiting medical officer of the Air Force. Six weeks previously he had had an attack of "flu." At the same time he noticed that he became hoarse. Ever since this illness, he was unable to continue with his athletic training. He felt weak and noticed that his physical strength fluctuated from day to day.

He was twice medically examined and accepted for the Air Force. No radiological examination was included in those examinations.

For about two and a half months after being accepted in the Army, he participated in daily physical training exercises at the military camp. During this time he coughed in the morning, expectorated sputum, and suffered from marked dyspnoea after slight exertion. However, since the exercises at the camp were much less strenuous than the physical activities to which he had become adjusted during his training which preceded his "flu," he managed "to stick it." On 13.10.40, i.e., ten weeks after joining the Army, he reported sick. He suffered from lancinating pains in the left side of the chest, which were aggravated by deep inspiration. He was admitted to a military hospital where his condition was diagnosed as "pleurisy and pneumonia." Again, no radiological examination was made. After spending eighteen days in the ward, he was sent on sick leave. Two days later he felt extremely weak and tired, coughed and expectorated. At this stage he saw a medical practitioner who sent him to King George V Hospital for Tuberculosis in Durban (24.12.40).

On admission he was found to be in a weak general condition. His height was 5 ft. 11 ins. and his weight 135 lbs. (At the beginning of 1940 his weight had been 175 lbs.). His temperature was slightly elevated (97.4-99), his pulse fast (80-100), his respiratory rate, 20. His voice was husky, he expectorated much sputum, in which occasionally streaks of blood were found. Sputum contained numerous tubercle bacilli, and X-ray examination of his chest revealed massive disease of whole of left lung.

The patient's earlier history had been uneventful. One of his sisters had died young from "lung disease."

He is now under treatment.

COMMENT.

This is a case of a soldier who was accepted for active service while suffering from active tuberculosis. The diagnosis was missed during two medical examinations, which did not include radiography of the chest.

Prior to the first medical examination by the military authorities, the patient had just had "an attack of flu"; his voice had been husky ever since and he was losing weight at a rapid rate. *His physical efficiency, as measured by the standard of his athletic performances, had sharply deteriorated during the six weeks preceding the first recruiting examination.* He could no longer run two miles, play a game of rugby, or two sets of tennis, as he had done only a few weeks before. In fact, he now became breathless after very slight exertion. This change alone should have aroused the suspicion of the doctors. Furthermore, the patient volunteered the statement that one of his sisters had died at an early age from "lung disease."

For some time he was able to take part in the physical exercise at the camp, probably because he had been well trained before his illness. After a few weeks of military life, however, he broke down, and has been in hospital ever since. It is estimated that he will remain in hospital for at least six months.

The following is a conservative budget of the costs which this case is causing the State:—

Wages in Camp:			
5s. 6d. per day for 70 days	£19	5	0
Maintenance, etc.:			
5s. 6d. per day	19	5	0
Military Hospital 18 days:			
10s. per day	9	0	0
Travelling	7	0	0
Durban Hospital at least 6 months:			
10s. per day	90	0	0
Another 6 months (convalescence):			
10s. per day	90	0	0
Total	£234	10	0

Had he been diagnosed in August—

(1) He would not have been accepted in the Army and the State would not have been responsible for the expense incurred through his illness.

(2) It is estimated that his disease would have been arrested in three months. In this case the cost would have been only £45.

(3) The danger of infection of others would have been reduced to a minimum.

The problem in question is of very great public interest.

On November 20, 1940, Mr. Malcolm MacMillan, in the House of Commons, asked the Minister of Health to make it the rule that further measures be taken to prevent men from being passed fully fit for active service who later become casualties but have to be refused pensions as the disabling disease had been present prior to their enrolment. He also drew attention to the danger to the health of other men sharing confined service quarters with these men.

CASE 2.—F.G., European Male, Age 37 years.

This is a case of a 37 years old man who suffered from a slight cough, and who expectorated sputum for the past six months. The symptoms were not severe and as he had no other complaints, he did not consult a doctor.

The patient had been a well known athlete. For years he was accustomed to vigorous exercise. Every day he ran 3 miles, swam at least 600 yards and belonged to a rowing club. He rowed well enough to be a member of the representative Natal team that competed against Cambridge University in August, 1939.

About four months before his disease was diagnosed, he found that he could not swim more than 200 yards, instead of his usual 600. The decrease in efficiency occurred gradually. He thought he was getting old and "did not bother much." Then he noticed that he was very breathless when he rowed, so he gave up rowing as too strenuous. Later he found that he got very breathless when running. He put all this down to being "out of condition," and tried hard to exercise himself back to good health, but found that he became more and more tired.

On examination his weight was 148 lbs., height 5 ft. 7 ins.; temperature and pulse rate were normal; respiratory rate was 20-22 per minute. No clubbing of fingers was present. He had a slight cough, productive of sputum. It was ascertained that he had recently been steadily losing weight. Clinically, crepitations were heard over the upper thirds of both lungs, and there were signs of a cavity at the left apex.

Sputum: T.B. positive.

Blood:	*Hb.*	101%
	W.B.C. Total	6000/cu.mm.
	Diff. Polys.	73%
	Eosin.	1%
	Lymph.	23%
	Monos.	3%
	B.S.R. (*Cutler—1 hr.*)	15 m.m.

X-ray examination of Chest: *Right*—Scattered infiltration throughout lung.

Left—Infiltration at apex. Cavity at infraclavicular region.

COMMENT.

In this case it can be said retrospectively that the lung disease led at an early stage to a marked deterioration in the patient's physical efficiency. The fact that he had been an outstanding athlete naturally tended to obscure this symptom, notwithstanding its severity. Such observations emphasise our demand for the introduction of *quantitative* physical efficiency tests into clinical practice (Jokl, Cluver, Goedvolk and de Jongh). In this particular case, the diagnosis would have been made several months earlier, and treatment could have been started under more favourable conditions if the lowering of the patient's physical capacity had been considered as a serious symptom. The economic significance of the early diagnosis of tuberculosis has been stressed in connection with case 1.

CASE 3.—*H.A.M.*, *European Male*, *Age* 36 *years*, *Stoker*.

Since 1934 the patient had been a stoker on a tug in the Harbour Department, Durban, and had always felt perfectly fit. His duties were very strenuous. Ordinarily he used to work from 6 a.m. to 6 p.m. but since the outbreak of war and with the increased activity at the docks, his hours of work have increased. He has at times, worked from 6 a.m. to 10 p.m., receiving overtime pay. Meal times were irregular and uncertain.

For the last 6 months he at times felt " not quite up to his usual mark " and, although he was not severely ill, he reported sick on several occasions so that he could rest for 3 days at a time, " just to slack off a bit and take things easy." Prior to this he had never been ill. He ascribed his periodic indispositions to the extra work necessitated by the war. He smokes about 15-20 cigarettes a day. and for the past three months he has had a slight " cigarette cough." On December 1st, 1940, he returned to Durban on a tug from Port Elizabeth, being " fit but a bit tired." He continued stoking till the evening of the 17th December, but on waking next morning felt " out of sorts " and applied again for 3 days' leave, thinking he would feel fit after some rest. However, after the short holiday he was no better.

A few days later his sputum was blood stained and his doctor advised him to have his chest X-rayed. This was done and *pulmonary tuberculosis* diagnosed.

He was admitted to the King George V Hospital for Tuberculosis on the 15th January, 1941.

There was no family history of tuberculosis, and his own previous history was entirely negative. On examination his temperature was found normal; pulse rate was 80-84 per minute; respiratory rate 20; patient is of thin build, weighing 129½ lbs., his height being 5 ft. 11 ins. He had a slight cough and expectorated some sputum. There was no shortness of breath and his appetite was good. Patient is edentulous.

On clinical examination a few crepitations were heard over the right pulmonary apex in front.

No cardio-vascular abnormalities were detected.

Examination of sputum for tubercle bacilli gave a positive result. X-ray of chest showed that both apices were obscured. A cavity was found at the right infraclavicular region.

Blood Examination:	*Hb.*		100%
	W.B.C. Total		6,800/cu. mm.
	Diff.	Polys.	64%
		Eosin.	0%
		Lymph.	31%
		Monos.	5%
	B.S.R. (*Cutler*—1 *hr.*)		23½ mm.

COMMENT.

This man who had performed hard physical work, never complained of illness or fatigue till about 6 months ago. The *deterioration in his physical efficiency,* slight but apparent, as evidenced by his repeated desire to " take three days off for a rest," *definitely antedated his " cigarette cough."* Although he had been smoking since boyhood, he only developed a smoker's cough about 3 months ago.

The cavity seen at the right infra-clavicular region probably explains his feeling " off colour."

CASE 4.—*C.R., European Male, Age* 25 *years, Sailor.*

Since the age of 17, when he left school, he has been at sea. On board ship he was on duty for four hours, followed by eight hours' rest. He thus performed a total of fifty-six hours work per week. Physically, he had been a very fit man, having been capable of doing various kinds of hazardous and difficult work on cargo boats.

He has had a slight cough in the morning for the past two months which he ascribed to his smoking 25-30 cigarettes a day and which he completely ignored.

What he did, however, very much notice, particularly during the last two months, was the fact that *he tired more easily than before;* when he was " off watch " he now always wanted to lie down and rest. This was contrary to his usual habits and mode of life. Apart from his tiring more easily, he thought that he was quite fit. On arrival in Durban he expectorated some blood-stained sputum. However, it was only at the Captain's request that he consulted a doctor. His sputum was then found to contain tubercle bacilli.

There was no family history of tuberculosis, and his personal record was quite negative.

On admission his weight was 146 lbs., and he looked very fit. Temperature, pulse and respiratory rates were normal. He had a slight cough productive of a moderate amount of sputum. His appetite was good. His cardio-vascular system was entirely normal. Clinically, no abnormal respiratory signs were found. However, tubercle bacilli were found in his sputum, and X-ray examination of his chest revealed scattered lesions throughout the right lung, as well as cavitations in the infra-clavicular region and midzone. On the left there were scattered lesions at the base.

Blood Examination:	*Hb.*	100%
	W.B.C. Total	8,900/cu.mm.
	Diff. Polys.	78%
	Eosin.	1%
	Lymph.	21%
	Monos.	0%

COMMENT.

A knowledge of this man's history from the point of view of his *physical efficiency and the rapid deterioration of his formerly extraordinary working capacity* should have given the clue to the existence of pulmonary tuberculosis.

It must again be emphasised that any person in whom a sudden or gradual decrease of physical efficiency is discovered, should be suspected of suffering from pulmonary tuberculosis, especially if the condition is associated with cough, however slight this symptom may be.

CASE 5.—*Miss V.R., European Female, Age* 29 *years, Nursing Sister.*

This is a case of a hard-working nursing sister at a general hospital. In her free time she indulged regularly in such physical activities as tennis and horse-riding without any evidence of undue fatigue. In July, 1940, she first noticed that she tired more easily after tennis. At about the same time she noticed marked breathlessness after riding—two experiences which had never been in evidence before. At the beginning of October, 1940, she actually gave up riding because she considered it now too vigorus a form of exercise. She carried on with her work at the hospital but became subject of attacks of breathlessness which she thought indicated " commencing asthma."

She had a slight cough for the previous eighteen months; this symptom, however, had been in existence for such a long time before any physical disability became apparent that she ignored it completely and regarded it as a " mere cigarette cough."

Because of her attacks of breathlessness which occurred while she was on duty she was persuaded to undergo an X-ray examination which revealed the presence of pulmonary tuberculosis. She was admitted to the King George V Hospital on the 14th December, 1940.

Family and personal history were entirely negative.

On examination her weight was 136 lbs., her height 5 ft. 4¾ ins., and her temperature 97-99.6° F. Her cardio-vascular system was normal, blood pressure was 130/70 mm. Hg., and clinical examination of her respiratory system did not yield conclusive signs permitting a diagnosis. Sputum contained tubercle bacilli. X-ray examination of chest revealed a cavity about the size of a shilling at the left midzone, with thickened pleura below. The right side was apparently normal.

Blood Examination:	*Hb.*	92%
	W.B.C. Total	11,700/cu.mm.
	Diff. Polys.	66%
	Eosin.	5%
	Lymph.	26%
	Monos.	3%
	B.S.R. (*Cutler—*1 *hr.*)	14 mm. (Normal 0-8)

An artificial pneumothorax was at once induced, and, at a later date, a phrenic nerve crush was undertaken. The patient is at present under treatment and the disease has been brought under control.

COMMENT.

Here again we have an example of a hard-working and physically fit young woman who indulged in tennis and horse riding. A sudden deterioration of her physical efficiency was the first indication of her illness which later on proved to be tuberculosis. In association with her cough, this symptom should have led at a much earlier stage to a careful examination of her lungs.

CASE 6.—*G.H.*, *Female*, *Aged* 18 *years*, *Scholar*

This patient was a healthy, active school girl. She played tennis, sufficiently well to be chosen for the school team, took part regularly in gymnastics and swimming, gaining the Life Saving Certificate. In August, 1939, she was preparing for her Junior Matriculation when her menses, which hitherto had always been regular, did not appear. She consulted a doctor who told her that the amenorrhoea was due to her working for the Matriculation examination. Early in 1940 she noticed "short windedness" and tiredness after school sports (tennis, swimming, gymnastics and games).

In April, 1940, she caught a "bad cold" which she could not "shake off." She developed a slight cough productive of sputum. She then went to a doctor who "could find nothing wrong with her," but her mother insisted on an examination of her sputum, which was found to be T.B. positive.

She was admitted to the King George V Hospital for Tuberculosis on the 15th May, 1940.

Her father had died of pulmonary tuberculosis in 1927. Her own previous history yielded nothing of note.

On admission to the hospital she had a slight cough and expectorated some blood stained sputum. Her general condition was fair; her weight was 92 lbs., her height 5 ft. 1¼ ins., and her body temperature 99.8-101.2. Pulse rate was 92-100, and respiratory rate 24-28 per minute. There was slight clubbing of fingers. The cardiovascular system was normal.

Clinical examination of her lungs revealed an impaired percussion note with amphoric breath sounds and crepitations in the upper portion of both lungs. Sputum contained tubercle bacilli. The X-ray examination of the chest showed massive lesions at apex and infraclavicular region with scattered infiltration at midzone and base on the right side and massive lesions in upper two-thirds of the left lung.

Blood Examination:	*Hb.*	100%
	W.B.C. Total	11,800/cu.mm.
	Diff. Polys.	79%
	Eosin.	0%
	Lymph.	10%
	Monos.	11%
	B.S.R. (*Cutler—1 hr.*)	29 mm.

The patient's condition deteriorated steadily despite all treatment, and she died on the 9th September, 1940.

COMMENT.

This child who had been a good athlete, suddenly developed amenorrhoea, soon followed by a sharp deterioration in physical efficiency. In spite of her being seen by a doctor on several occasions since the appearance of the first symptoms, pulmonary tuberculosis was not suspected until the mother insisted on a sputum examination in May, 1940.

If notice had been taken of the fairly sudden decrease of the patient's physical efficiency, the disease might have been diagnosed earlier. The importance of this point should be stressed at all schools.

SUMMARY AND CONCLUSIONS.

Every individual has his own standard of physical efficiency. If this standard is suddenly lowered, the possibility of pulmonary tuberculosis being present should always be considered. It is not justifiable to incriminate advancing years, heart disease, or "lack of sleep," unless very clear evidence is available in this respect. ***The most common cause of sudden physical deterioration in a young person is pulmonary tuberculosis.***

Emphasis is laid on the necessity for closely inquiring, *if possible in quantitative terms,* into the physical performance standards of a person in assessing disease, particularly in discovering early cases of tuberculosis. Six cases are presented.

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A SUGGESTION AS TO THE NATURE OF CANCER AND ABNORMAL GROWTH

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Abstract.

A theory for the causation of all forms of abnormal growth, including cancer, is proposed. It is suggested that these are release phenomena. The normal cell obtains its energy by two processes: firstly, glycolysis, or the breakdown of sugar or glycogen to lactic acid, in which the stored ultra-violet energy of the sun is liberated, and secondly, respiration, or the oxidation of lactic acid to carbon dioxide and water. There is much evidence to show that the second process controls the first (Pasteur effect). If there is a deficiency in any of the substances necessary for respiration, such as vitamins A and B_2 and nicotinic acid, the more primitive process of glycolysis preponderates, and manifests itself as a kinetic tendency to proliferate. This accounts for the epithelial hyperplasia seen in these vitamin deficiencies.

A theory as to the role of vitamin A in cellular metabolism is discussed.

It is suggested that the cause of cancer is a permanent destruction of one of the cellular respiratory systems, viz., the Warburg-Keilin or oxidase-cytochrome system. The evidence in support of this is abundant. It is suggested that a normal function of this system may be the resynthesis of hexoses from substrates, apart from the oxidation of substrates to CO_2 and water. A permanent destruction of this system results in a high glycolysis, and from this process the cancer cell obtains its energy.

The theory explains also the growth of cells in tissue culture, in virus diseases, and that due to certain hormones, viz. oestrin.

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THE ANTERIOR BLOOD-VESSELS OF *XENOPUS LAEVIS*

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Xenopus laevis is an interesting African Anuran that, perhaps partly on account of its aquatic habitat, differs morphologically in certain respects from the more typical Anuran condition as exemplified by Rana. These anatomical differences are evident in both larval and adult conditions, and one of the most interesting relates to the pharyngeal region. During development the Anuran larva is characterized in its early stages by the presence of three pairs of external gills which are soon suppressed, respiration being then performed by internal gills. The circulation of the blood to and from these structures is essentially piscine in plan, so that the developmental stages of Amphibia have proved valuable sources of information regarding the evolution of the main blood-vessels of adult Tetrapoda from the system of vessels obtaining in Pisces.

Xenopus, being a purely aquatic Amphibian, might be expected to give an even clearer indication of the piscine arrangement than other Anura, but the present observations show that this does not obtain. In the early larval stages, shortly after hatching and before the mouth opens, the external gills are merely protuberances of the lateral body-wall in the pharyngeal region. The first eg.$_1$, Fig. 1) and the second (eg.$_2$) pairs of external gills are fairly obvious in sections, but the third pair is inconspicuous. These structures are transient and may be seen in larvae measuring from 5 mm. to 5.75 mm. but have disappeared in larvae having a total length of 7 mm. and in which the mouth has opened. In the earliest stages there are no cartilaginous branchial arches, but after the mouth opens, and throughout the remainder of larval life, there is a wide pharyngeal region which has three pairs of gill-slits (gc. $_{1-3}$, Fig. 2) and which is supported by four pairs of cartilaginous bars (cba. $_{1-4}$, Fig. 2). The whole region is enclosed by the external body-wall, the water entering through the mouth and flowing out through the paired spiracula situated laterally near the posterior extremity of the third gill-slit. As may be observed in Fig. 2, the inner wall of this region is not provided with gill-filaments as in other Anura. It is merely thrown into slight protuberances, and while it may act as a respiratory tissue, it must also be largely a filtering apparatus as Peter (1930) has suggested.

In view of these morphological peculiarities in Xenopus, the blood-supply to and from the pharyngeal region affords an interesting study. The following remarks are based upon observations of serial sections of larvae, ranging from those with the mouth closed and having a total length of 5 mm., to recently metamorphosed specimens in which only a short stump of the larval tail is still evident.

AORTIC ARCHES.

In the youngest stages examined three pairs of aortic arches (aa. $_{1-3}$, Fig. 3) are developed and the condition somewhat resembles that described and figured by Maurer (1888) in young Rana larvae measuring 5 mm., in which, as in Xenopus, there are short protuberances of the first and second external gills. In Xenopus, however, the external gills do not develop further and the rudiments of the third pair remain inconspicuous. Each arterial arch arises ventrally from a short arterial trunk, and coursing laterally and dorsally, the three of each side unite to form the lateral dorsal aortae (lda., Figs. 1 and 3). Each arch, therefore, consists of ventral and dorsal portions, but owing to the absence of true gills, the differentiation into afferent and efferent vessels does not obtain. Laterally, two very short vessels are associated with each of the first two pairs of aortic arches. They pass into the ectodermal protuberances that represent the rudiments of the external gills of other Anura In each rudiment the vessels join, forming a very short continuous loop that seems to be similar to the secondary vessels described and figured by Maurer in young larvae of Rana. The secondary vessel of the third arch was not observed, and the main vessel itself (aa. $_3$, Fig. 1) was only traced with difficulty.

From the first aortic arch a ventral or external carotid artery (ec., Fig. 3) is given off, and there is apparently no other earlier indication of the arteria hyomandibularis as observed in Rana by Maurer. The anterior continuation of the lateral dorsal aorta forms the dorsal or internal carotid artery (ic., Fig. 3). Posteriorly, in the region of the pronephros, the two aortae join to form the median dorsal aorta (mda., Fig. 3). An artery is given off from each lateral dorsal aorta behind the third pair of aortic arches. It can only be traced on each side as far as the pronephros and seems to represent the future subclavian artery.

Bles (1904) has suggested that the larval tentacle represents the external gill of the mandibular arch, but in these early stages the tentacle has not yet appeared, and there are no traces of external gills, either in this or the hyoïd arch. Nor is his suggestion confirmed by examination of subsequent stages (Fig. 2), in which both the tentacles and visceral arches are evident, but in which there are no external gills. It seems more likely, as H. K. Pusey has suggested in a personal note to the writer, that the tentacular cartilage represents a chondrified extension of the trabecular ligament described by him (1938) in Rana.

When the external gills disappear and the pharyngeal region becomes defined by the presence of branchial arches and gill-clefts, another picture of the aortic arches is presented, and one which differs somewhat from that of typical Anura. Owing to the absence of true gills, there is no short-circuiting of afferent and efferent vessels as described by Robertson (1913) and Graham Kerr (1919). In all stages after the opening of the mouth and up to the time of metamorphosis, the aortic arches are evident as three pairs of obvious channels (aa. $_{1-3}$, Figs. 4 and 5), passing from their ventral trunk to the branchial region, but the actual supply given off from the main arches to the branchial wall is somewhat difficult to trace. Compared with the early stages, it may be noted that the second and third arches have lost their connection with the lateral dorsal aorta. The main part of the second arch (aa. $_2$, Figs. 4 and 5) can only be traced as far as the second gill-slit, after which the supply to the first and second branchial arches (ba. $_1$, ba. $_2$, Fig. 5) is given off. The third aortic arch, after supplying the third and fourth branchial arches (ba. $_3$, ba. $_4$, Figs. 4 and 5) continues posteriorly as the pulmonary artery (pul.). The delicate arteries to the second and third branchial arches extend laterally (Fig. 5) to unite with an equally delicate artery lying immediately outside the branchial skeleton. This artery is continued anteriorly and posteriorly into vessels ending in the wall of the branchial region, but there is no connection between it and the lateral dorsal aorta.

As in earlier stages, the external carotid artery (ec., Figs. 4 and 5) arises from the first aortic arch shortly after the latter leaves the truncus arteriosus. It passes forward between the two halves of the branchial skeleton and comes to lie between the ceratohyal and the interhyoideus muscle. On its course small arteries are given off to the thyroid gland, the interhyoideus muscle and the floor of the mouth. After the external carotid artery has been given off the first aortic arch courses laterally and then dorsally, and after passing backward for some distance, it joins its counterpart of the opposite side, forming the median dorsal aorta (mda., Figs. 4 and 5). About halfway along the course of the first arch, and as it curves dorsally, the dorsal or internal carotid artery (ic., Figs. 2, 4 and 5) is given off, so that during most of larval life this arch appears to represent a combination of both the first and second arches of other larval Anura. The internal carotid artery runs forward beneath the chondrocranium. From it a cerebral artery is given off, while the main internal carotid artery courses forward to supply the palate and the muscles and tissues of the snout (as., Fig. 5). The cerebral artery (ca., Figs. 4 and 5), after entering the cranial cavity through the carotid foramen, divides into two, one branch supplying the brain, while the other artery, the arteria ophthalmica (oph.a., Fig. 5) leaves the cranial cavity via the oculomotor foramen, and passing into the orbit supplies the eyeball and eye-muscles.

During metamorphosis the second arch undergoes some change While the supply to the branchial arches remains constant, the main part of the second arch, which until now had been very short, is continued laterally and dorsally until it meets the dorso-lateral part of the first arch a short distance behind the origin of the internal carotid artery (Fig. 6). The third arch remains distinct and does not join the dorsal aorta. It follows, therefore, that the condition is approaching that of the adult. The first or carotid arch is, however, now joined to the second or systemic arch by a short lateral part of the original dorsal aorta, and this connection (d., Fig. 6) represents the ductus caroticus found in many larval Anura and Urodela. In the majority the ductus is evident throughout larval life, but in Xenopus it disappears after the mouth opens and only reappears for a short time during metamorphosis. Towards the end of metamorphosis the ductus caroticus narrows considerably (d., Fig. 7), and when metamorphosis is completed the ductus has atrophied, with the result that in the adult there is no connection between the carotid (car., Fig. 8) and systemic arches (sys., Fig. 8).

VEINS.

In the larva the blood is returned from the head region to the sinus venosus in three main vessels, two jugular veins and the anterior cardinal or head vein. The more dorsal and more median of the two jugulars (ex.j.$_1$, Figs. 2 and 9) begins in the floor of the mouth above the Meckel's cartilage. and running posteriorly above the cerato-hyal it continues in a median position between the two halves of the branchial skeleton (ex.j.$_1$, Fig. 2) receiving branches from the thyroid gland. It is joined by vessels from the medial and dorsal walls of the branchial region (dv., Fig. 9) and also by two main veins from the branchial arches, the anterior of which (bv.$_1$ and $_2$, Fig. 9) runs from the first and second branchial arches, while the posterior (bv. $_3$ and $_4$) returns the blood from the third and fourth arches. The main jugular vein continues beyond the level of the sinus venosus and enters the ductus Cuvieri (dc., Fig. 9) dorsally. The other jugular vein (ex.j.$_2$, Figs. 2 and 9) runs from the intermandibular and interhyoideus muscles and is ventral in position to the wall of the branchial region, from which it may receive very small vessels. It passes directly into the sinus venosus (sv., Fig. 9) a short distance in front of the entrance of the Cuvierian duct into the sinus venosus. These two veins seem to represent the jugular and ventral external jugular veins described by Goodrich (1930) and the inferior jugular vein of Lepidosiren observed by Robertson (1913) and Graham Kerr (1919).

The head vein (acs., Fig. 9) seems to be comparable with the anterior cardinal and the lateral cephalic veins of Lepidosiren (Robertson) and with the vena capitis lateralis of Goodrich. It is located dorsally above the pharynx, where throughout most of its course it runs parallel to the internal carotid artery in a ventral groove of the chondrocranium below the crista parotica. Its posterior end, like the anterior cardinal vein of Lepidosiren, becomes continuous with the pronephric sinus (ps., Fig. 9), from which the Cuvierian duct (dc.) runs forward at an angle to join the sinus venosus.

The head vein is formed by two main vessels, one of which (v., Figs. 2 and 9) passes back from the dorso-lateral wall of the pharynx and the thymus gland (th., Fig. 2). As the anterior and posterior cerebral veins mentioned by Goodrich (1930) are not evident in the larvae of Xenopus, the other vein (vcm., Fig. 9) appears to correspond to the vena capitis medialis of other forms. It conveys the blood back from the orbit and brain and joins the anterior cardinal vein laterally. The large cerebral vein (cv., Figs. 2 and 9) makes its exit from the cranial cavity through the foramen prooticum together with the nerves from the ganglion prooticum. On leaving the cranial cavity, the cerebral vein is joined by the vessel returning the blood from the snout and the orbit (oph.v., Fig. 9).

On metamorphosing, the Cuvierian ducts of the larva shorten and become the superior venae cavae (svc., Fig. 10), which enter the sinus venosus just in front of the inferior vena cava (ivc., Fig. 10). Each superior vena cava is formed by three main veins which are directly comparable with those of the larva, and are similar to those of Rana (Gaupp, 1899). The external jugular (j., Fig. 10), which passes dorsally over the hyoid returning blood from the floor of the mouth, enters the superior vena cava close to the sinus venosus and seems to represent the jugulars of the larva. The innominate vein (inn.) of the adult is formed by the ophthalmic (oph.v.) and cerebral (cv., Fig. 10) veins and is, therefore, directly comparable with the vena capitis medialis (vcm., Fig. 9) of the larva, in which, after the cerebral vein leaves the cranial cavity to join the ophthalmic, it curves backward and unites with the anterior cardinal vein. The remaining cephalic vein of the larva is the one from the dorsal wall of the pharynx (v., Fig. 9). This appears to be transformed into the cutaneous vein of the adult (cutv., Fig. 10), in which it is joined by the brachial vein (brv.) so that the two together constitute the subclavian vein (sub., Fig. 10).

From the foregoing, it is evident that in Xenopus, owing to the absence of true external and internal gills, the branchial region is not essentially respiratory as in other Anura. Even in young larvae after the mouth opens, the lungs and the pulmonary arteries and veins are evident, and the heart already consists of three chambers (Fig. 2), so that a double circulation of the blood is accomplished before metamorphosis. It follows, therefore, that the pharyngeal region in Xenopus larvae, like other parts of the body, is supplied with arterial blood, and that at metamorphosis the small branchial vessels atrophy. On the whole, the course of the main arteries and veins is comparable with that observed during the development of other Anura, but in Xenopus there is a greater degree of similarity between larval and adult arrangements than in other forms.

SUMMMARY.

1. An account is given of the course of the main arteries and veins in the larvae of Xenopus before and after the opening of the mouth.
2. In the earliest stages the arrangement of the aortic arches is similar to that of young larvae of Rana, but throughout the major part of larval life, the first arch of Xenopus seems to be a combination of the first and second arches of other Anura.
3. During metamorphosis the second aortic arch extends laterally to unite with the first, so that a ductus caroticus is temporarily established between them.
4. The course of the main cephalic veins of Xenopus is essentially like that of other Anura.
5. It is considered that the branchial region of Xenopus does not appear to be respiratory in function. There are no true external or internal gills. Even in young larvae after the mouth has opened, the lungs are evident, and judging by their morphology they seem to be functional, for to and from them there pass the pulmonary arteries and veins respectively.

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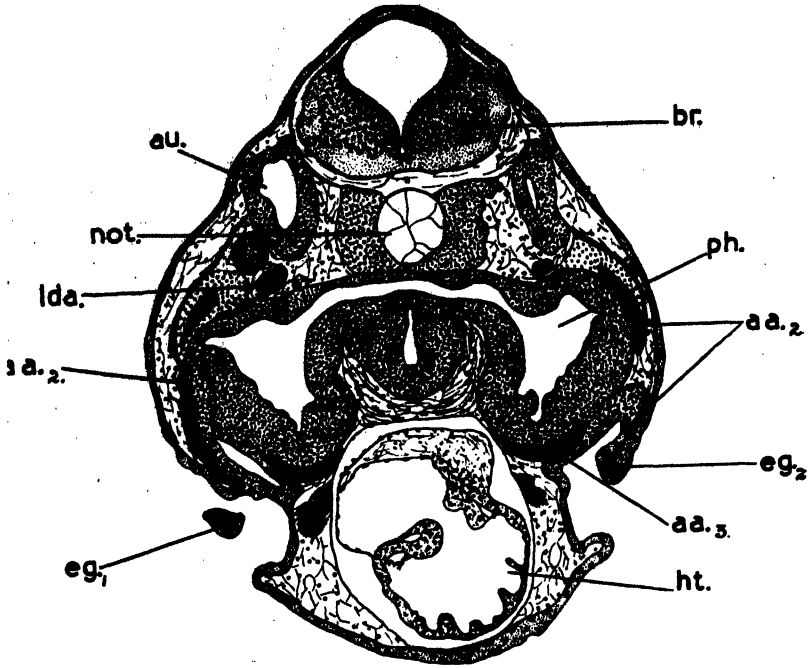

Fig. 1. Transverse section through the pharyngeal region of a Larva measuring 5.75 mm. in total length. The section passes through the region marked X—X in Fig. 8. X 41.

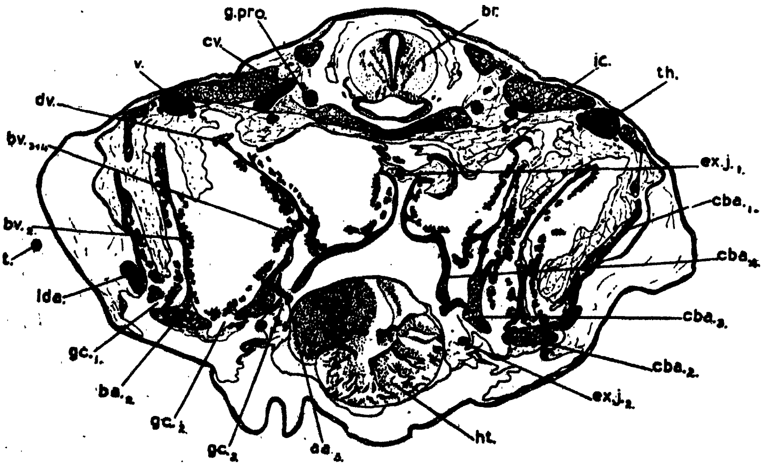

Fig. 2. Transverse section through the branchial region of a Larva measuring 60 mm. in total length. The section is taken through the line X—X in Fig. 9. X 6.25.

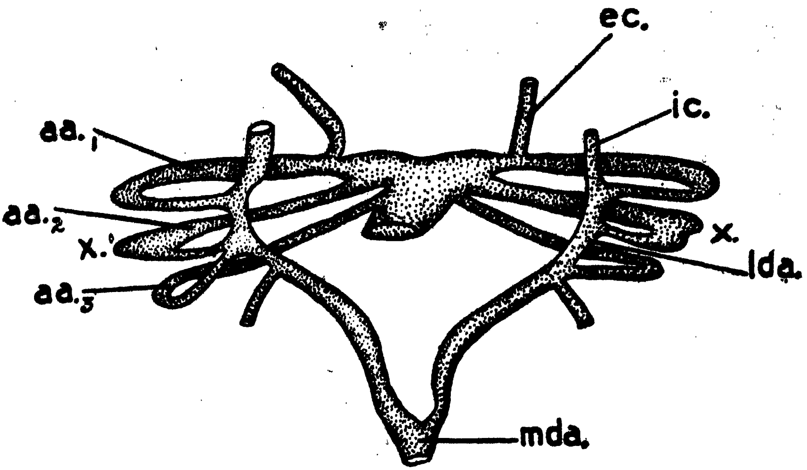

Fig. 3. Reconstructed from transverse sections of the aortic arches in an early Larval stage before the mouth opens. Dorsal view. X 100.

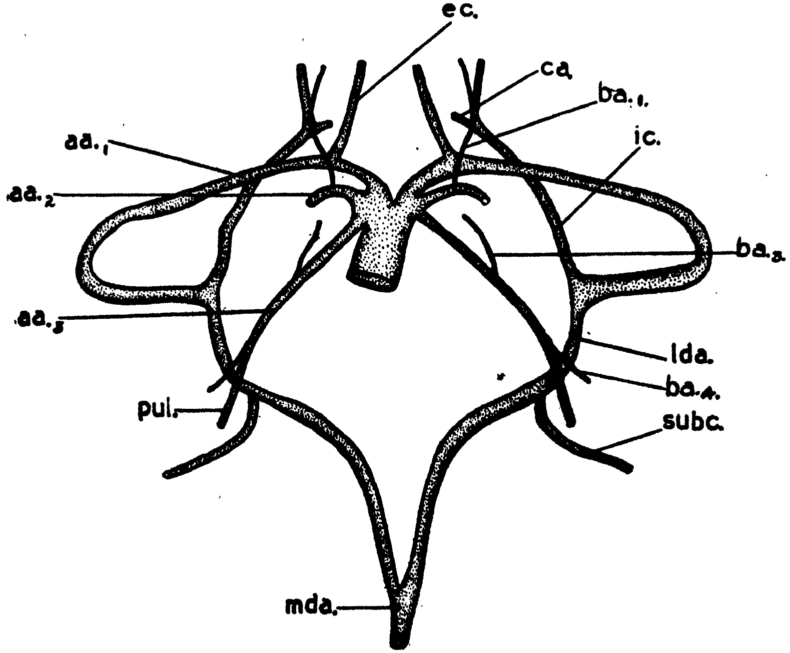

Fig. 4. Reconstruction of aortic arches and some of the branchial arteries in a larva measuring 10 mm. Long Ventral view. X 18.5.

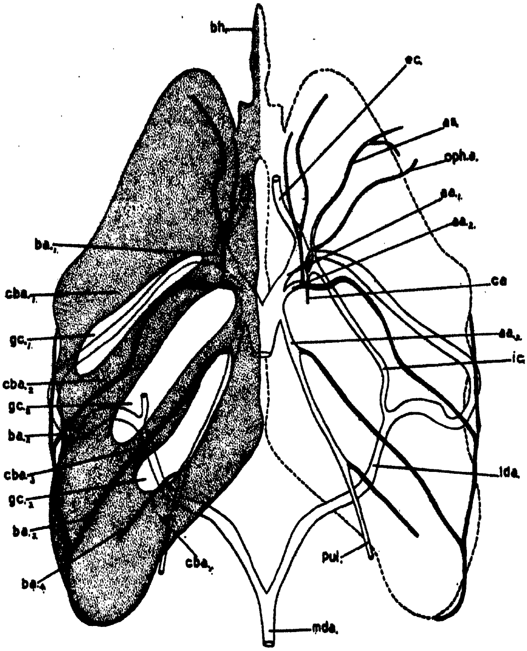

Fig. 5. Reconstruction of aortic arches and branchial arteries in a larva measuring 28 mm. long. The subclavian arteries have been omitted and the branchial skeleton has been outlined to show the position of the aortic arches in relation to the branchial arches and gill-slits. X6.6.

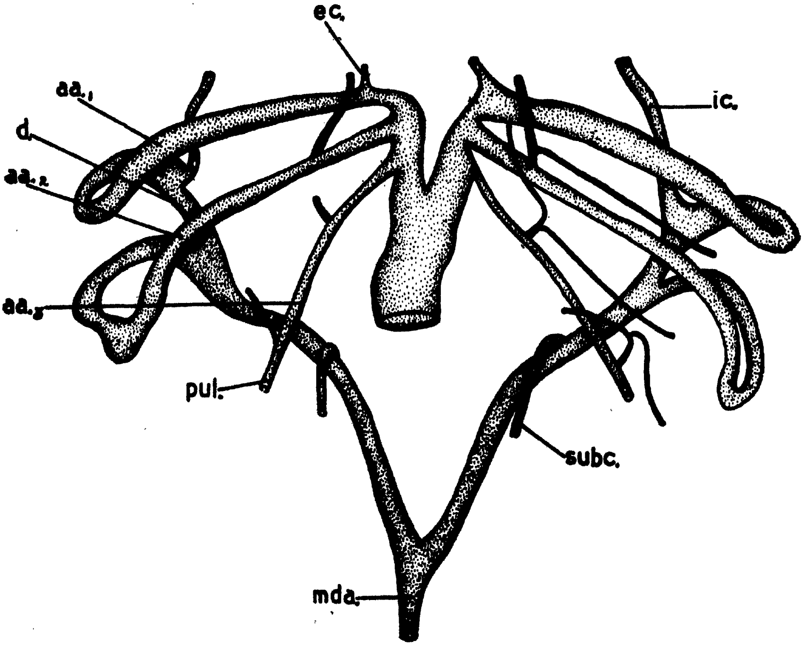

Fig. 6. Reconstruction of the aortic arches shortly after metamorphosis has started. Ventral view. X 9.9.

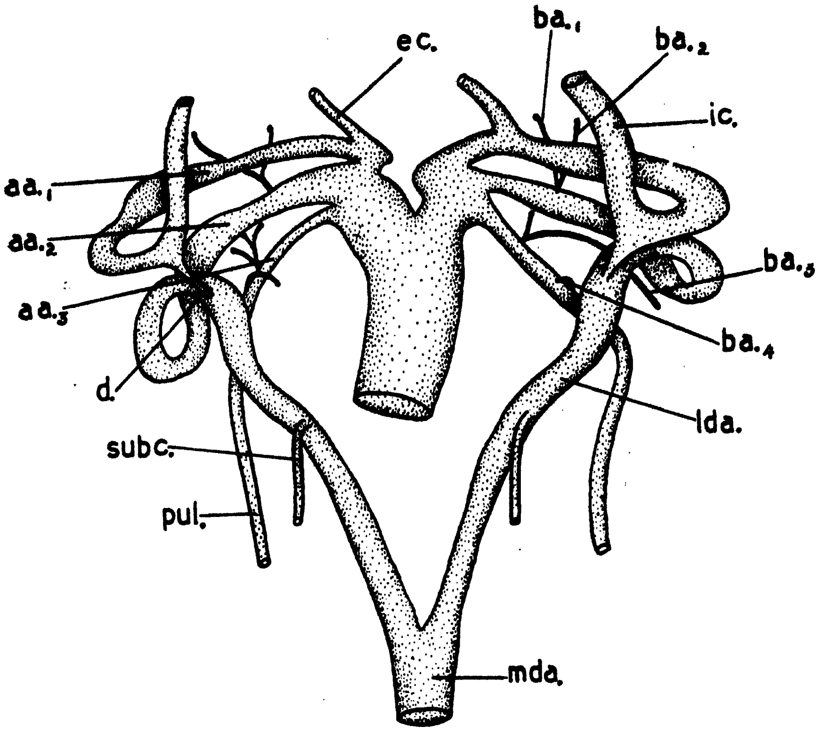

Fig. 7. Reconstruction of the aortic arches before the completion of metamorphosis. Dorsal view. X 10.8.

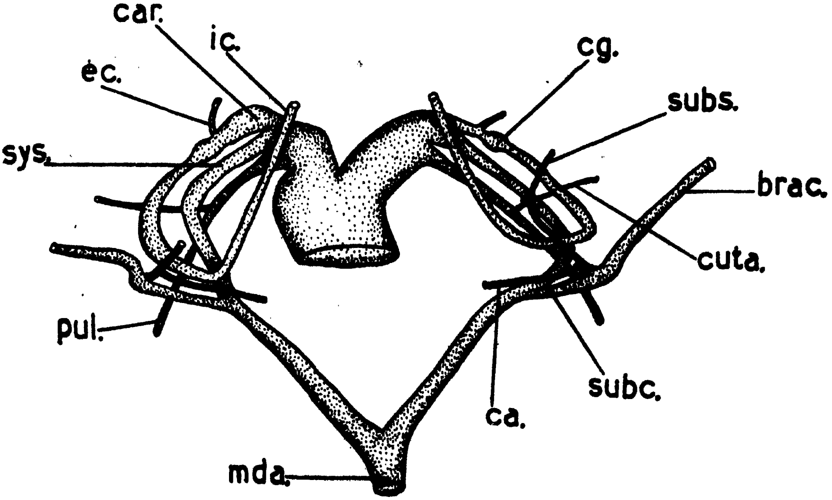

Fig. 8. Reconstruction of the aortic arches in a recently metamorphosed specimen. Dorsal view. X 25.

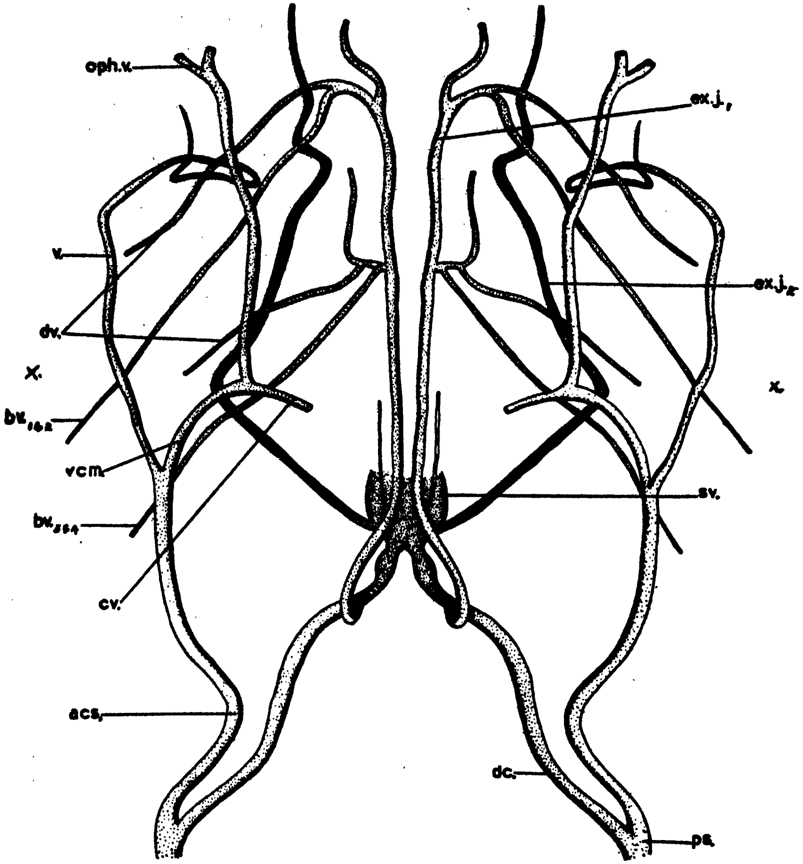

Fig. 9. Reconstruction of the branchial veins in a larva measuring 60 mm. long Dorsal view. X 8.8.

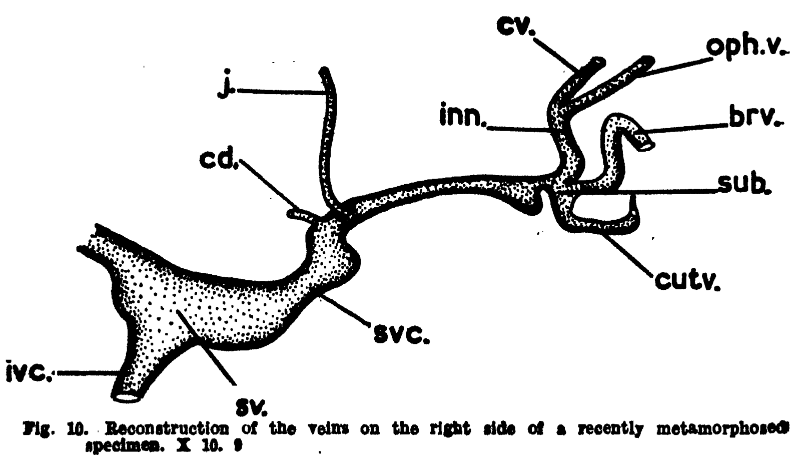

Fig. 10. Reconstruction of the veins on the right side of a recently metamorphosed specimen. X 10. 9

ABBREVIATIONS USED IN THE FIGURES.

aa.$_1$, aa.$_2$, aa.$_3$, aortic arches of the larva; acs., anterior cardinal vein; as., artery to the snout and palate; au., ear; ba.$_1$, ba.$_2$, ba.$_3$, ba.$_4$, branchial arteries; bh., basihyal; br., brain; brac., brachial artery; brv., brachial vein; bv. $_1$ and $_2$, bv. $_3$ and $_4$, branchial veins, ca., cerebral artery; car., carotid arch; cba. $_1$—$_4$, cartilaginous branchial bars; cd., cardiac vein; cg., carotid gland; cuta., cutaneous artery; cutv., cutaneous vein; c.v., cerebral vein; d., ductus caroticus; dc., ductus Cuvieri; dv., veins from the dorsal wall of the branchial region; ec., external carotid artery; eg.$_1$, eg.$_2$, rudiments of external gills; ex.j.$_1$, ex.j.$_2$, jugular veins of larva; gc.$_1$, gc.$_2$, gc.$_3$., gill-clefts; g.pro., ganglion prooticum; ht., heart; ic., internal carotid artery; inn., innominate vein; ivc., inferior vena cava; j. external jugular vein of adult; lda., lateral dorsal aorta; mda., median dorsal aorta; not., notochord; oph.a., ophthalmic artery; oph.v., ophthalmic vein; ph., pharynx; ps.. pronephric sinus; pul., pulmonary artery; sub., subscapular vein; subc., subclavian artery; subs., subscapular artery; sv., sinus venosus; svc., superior vena cava; sys., systemic arch., t., tentacle; th., thymus gland; v., vein from thymus gland and dorsolateral wall of branchial region; vcm., vena capitis medialis.

A NOTE ON THE DEVELOPMENT AND SURVIVAL OF TEETH, ESPECIALLY SELACHIAN

BY

F. GORDON CAWSTON, *Durban.*

Read 30th June, 1941.

THE PROBLEM OF UNDEVELOPED FANGS IN OPISTOGLYPHA

BY

F. GORDON CAWSTON, *Durban.*

Read 30th June, 1941.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XXXVIII, pp.* 292-297.
January, 1942.

THE WEIGHT AND VOLUME OF THE HYPOPHYSIS CEREBRI IN THE MALE BANTU

BY

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Read 30th June, 1941.

The first paper from this Department on the weights of the endocrine organs in the Bantu was written by the late Dr. J. F. Maingard (1935). These results were discussed by Pearl (1937). The present paper is a statistical study of pituitary weights and volumes, from data collected at autopsies during the period 1935 to 1937 and supplied to the writer by Dr. Joseph Gillman.

METHODS AND DESCRIPTION OF MATERIAL.

The glands were fixed and preserved in 10% formalin, as soon as possible after death, in most cases within 48 hours. Before weighing, the stalk of the hypophysis was cut off as near as possible to the body of the gland. The outer or dural membrane was removed from the anterior lobe. It was carefully trimmed along the groove between the anterior lobe and the posterior lobe. The thin membrane below the dura was also carefully removed. In the region of the posterior lobe a certain proportion of connective tissue remained, which could not be removed without injuring this part of the gland. The quantitative data given apply to the whole gland, including the pars distalis (anterior lobe), processus infundibuli (posterior or neural lobe), and that portion of the juxtaneural glandular tissue which lies between the two structures, and is designated the pars intermedia (intermediate lobe), thus making the data comparable with the figures given by Rasmussen (1938).

The glands were weighed on an ordinary balance, correct to 10 mg. The volume was determined by the displacement of distilled water in a small measuring cylinder, care being taken to avoid errors due to parallax.

THE PRESENT MATERIAL.

The age distribution of the cases from which the pituitaries were obtained is shown in the following table. The ages are given as stated in the autopsy records.

With reference to the causes of death in the present series, in the cases of adults the causes were traumatic in most cases, such as machinery accidents and stab wounds. In the following table detailed causes of death are given in cases other than traumatic.

TABLE I.

CAUSES OF DEATH.

Age	Traumatic	Not stated	Other	Total No. of Observations For Wt.	Total No. of Observations For Vol.
0–1	1	—	3 stillborn ; 2 premature ; 1 suprarenal apoplexy ; 1 bronchopneumonia ; 2 gastric enteritis; 2 pneumonia and enteritis ; 1 cerebral haemorrhage ; 1 poisoning.	14	13
10–15	1	—	1 pneumonia ; 1 infective endocarditis.	3	3
16–20	3	—	1 generalised septicaemia.	4	4
21–25	17	2	1 ruptured aneurism into trachea.	20	18
26–30	22	8	2 pneumonia ; 1 ruptured aortic aneurism ; 1 septicaemia ; 1 cardiac failure ; 1 hydrocephalus obstruction ; 1 pneumococcal meningitis ; 1 tuberculosis.	38	30
31–35	6	2	2 pneumonia : 1 aortic aneurism ; 1 tetanus ; 1 typhoid ; 1 cardiac failure.	14	13
36–40	15	3	1 chronic nephritis ; 2 general peritonitis.	21	20
41–45	1	—	3 pneumonia ; 1 cancer of lung.	5	5
46–50	6	8	2 pneumonia ; 1 subacute nephritis ; 1 tuberculosis ; 1 myocardial degeneration.	19	11
51–80	2	4	1 cirrhosis of liver ; 1 aortic incompetence, cardiac failure ; 1 aortic aneurism ; 1 pulmonary tuberculosis.	10	6

As has already been stated above the pituitaries of Bantu males will be discussed only in relation to total weight and volume in the present paper. The statistics for weight and volume for the various age groups from birth to 50 years are given in Table 2.

TABLE 2.
STATISTICS FOR WEIGHT AND VOLUME IN BANTU MALE PITUITARIES.

Age	Weight in grams					Volume in cubic centimetres				
	Mean	S.D.	S.E.	C. of V	Range	Mean	S.D.	S.E.	C. of V.	Range
0–1	·10	·0424	·0114	42·4	·08–·24	·13	·0541	·0164	41·60	·075–·275
10–15	·51					·48				
16–20	·55					·52				
21–25	·60	·2774	·0620	46·20	·45–·82	·60	·2685	·0633	44·80	·50 –·80
26–30	·58	·1130	·0183	19·34	·39–·81	·64	·1340	·0244	20·85	·35 –·91
31–35	·57	·2624	·0701	46·04	·45–·69	·58	·2826	·0784	48·72	·45 –·70
36–40	·58	·1158	·0253	19·97	·48–·81	·57	·1291	·0288	22·64	·35 –·80
41–45	·56	·0942	·0042	16·82	·49–·70	·63	·1777	·0794	28·21	·45 –·90
46–50	·50	·2747	·0630	54·94	·35–·71	·47	·1083	·0327	23·04	·30 –·70

It will be noticed from Table 1 that the numbers of cases in each half decade after 50 years are so small as to preclude analysis of these figures in five-yearly groups. The individual values in each of these age groups are given in Table 3.

TABLE 3.
WEIGHTS AND VOLUMES OF PITUITARIES IN INDIVIDUAL CASES OVER 50 AND BETWEEN 10 AND 20 YEARS OF AGE.

Age	Weights in grams				Volume in cubic centimetres			
51–55	·4	·39	·67		·4	·35		
56–60	·37	·54			·4	·5		
61–65	·54	·70						
66–70	·49				·5			
71–75	·54				·5			
76–80	·59							
10–15	·41	·46	·65		·4	·45	·60	
16–20	·61	·55	·54	·52	·50	·55	·50	·55

In the calculation of the S.D.'s and S.E.'s, the data were grouped only for the age group 26-30. For the other age groups the data were not grouped into classes, but the S.D.'s were calculated by the long method. For these groups N-1 was used in calculating the S.D., where N=number of cases in age group.

Discussion of Present Data.

The growth curves in weight and volume of the pituitary are plotted on ordinary co-ordinate paper in Chart 1. It will be noticed that, while the curve for volume roughly follows that of weight, there are discrepancies at certain ages. For instance, the volume of the gland appears to increase between

25 and 30 years, while the weight remains more or less constant. There is another increase in volume between 40 and 45 years. These different trends in the growth of weight and volume are more clearly shown in Chart 2, where the percentage rates of increase of weight and volume with age are shown. The weights and volumes in each age group are expressed as a percentage of the gain in these figures between the value in the age group 0-1 years and the value for the age group 46-50 years.

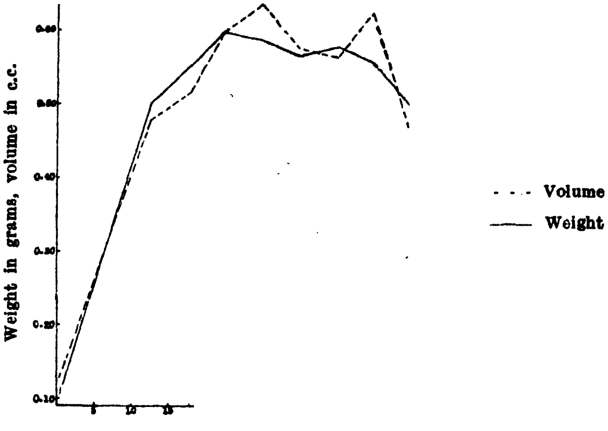

CHART 1. Absolute increase in weight and volume of the Pituitary in Bantu Males

Chart 2 shows that the curve for weight forms a peak at about 22 years, falls to about 32 years, then forms another peak at about 37 years, after which it falls to about 47 years. Values are not plotted after this age.

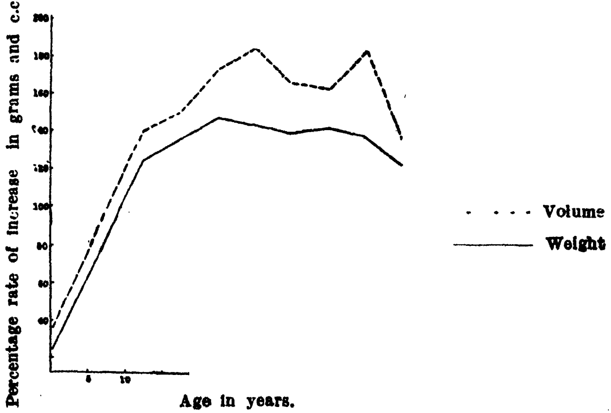

CHART 2. Percentage increase in weight and volume of the Pituitary in Bantu males, using differences between values at 6 months and 47.5 years as denominator.

The growth curve for the weight of the hypophysis cerebri as shown in Chart 2 is closely similar to the generalised curve given by Rasmussen (1938) for the growth of the whole pituitary in European males. The only difference between the two curves is that the Europeans appear to be older than the Bantu when the growth changes takes place. For instance, the first peak is reached by the Bantu males between 20 and 25 years. The first peak for Europeans appears between 30 and 40 years. The second peak is shown by the Bantu between 35 and 40 years while the Europeans show the increase at 70 years.

Rasmussen (1938) states that "in adult men the weight of the whole gland does not change with age as much as some of its parts, because, while pars distalis decreases after middle age, processus infundibuli and the epithelial elements of pars intermedia tend to increase with age. Apparently as one approaches the age of fifty years, pars distalis is declining in weight and continues to do so faster than the gland as a whole, because in later years pars intermedia and processus infundibuli increase sufficiently to counteract to some extent the decline in the pars distalis."

Whether these differential growth trends are similar in the Bantu pituitary is as yet unknown.

Rasmussen (1938) points out that Negroes have a larger pituitary than white people. Pearl et al. (1935) agree with this finding, but state that the differences are generally not statistically significant. Rasmussen finds European male pituitaries to weigh .526 grams on the average in the age-group 20-76 years (111 cases). Present data are .600 grams in age-group 21-25 (20 cases), and .560 grams in the age-group 41-45 (5 cases).

The weights of the Bantu pituitaries in other age groups are given in Table 3. It will be noticed that the Bantu pituitary in the age group 46-50 weighs 500 grams, which is less than the mean given by Rasmussen.

Further investigation is required before it can be stated with any degree of certainty whether the growth of the Bantu male pituitary is different in any significant degree from that of the European, especially in view of the fact that the ages given for the Bantu are not accurate. In the hospital and at post mortem every effort was made to ascertain the age as accurately as possible in cases of doubt. In the case of adults, one does consider that the estimated age is within five years of the actual age. In the case of children the estimates are more accurate.

SUMMARY

The weights and volumes of 148 Bantu male pituitaries, ranging from observations at birth to 80 years, are recorded. Most (i.e. 117) of the observations lie between 20 and 50 years.

The weight curve is similar to that given by Rasmussen for European males, with the exception that the changes appear to take place earlier in the Bantu.

The growth in volume does not take place at the same rate as that in weight. The volume curve shows two peaks, at 27 years and at 42 years, not shown in the weight curve.

ACKNOWLEDGMENTS.

I want to thank Dr. Joseph Gillman for his encouragement and for placing the data on the pituitaries at my disposal. The post mortem material was furnished through the courtesy of Professor Mackintosh, Department of Forensic Medicine and of Professor A. S. Strachan, and Drs. Chatgidakis and Becker, of the Department of Pathology.

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January, 1942.

MEASUREMENTS OF THE MALE ZULU FEMUR

BY

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With 1 Table. Read 30th June, 1941.

While working in the Department of Anatomy I have had the opportunity of examining 50 pairs of male Zulu femora. This investigation formed part of a study on the technique of measurement of the femur undertaken by this Department at the instance of the International Committee for the Standardization of Anthropometric Technique. Out of the large number of measurements of various kinds which have been taken, it has been considered worth while to place on record the results obtained for those measurements most generally in use. To my knowledge no such data for any South African Negro group has hitherto been published, and it is hoped that these observations may be of value to other investigators. No attempt will be made here to compare the measurements for the Zulu with those of other physical types.

Table I presents the range, mean, standard error and standard deviation for the selected measurements and indices. These data are given for the right and left femur separately and also for the two series combined. In all cases it has been found that the difference between the mean values for right and left sides is statistically insignificant. It may be mentioned that in one or two instances it was not possible to obtain a satisfactory measurement upon both femora of a pair.

Of the absolute measurements, only the lengths call for discussion. It will be seen that the maximum length varies over a range of 11 cms. (40-51 cms.). Within this range the individual measurements show a very normal distribution about the mean value of 45.53 cms. Thus only two femora have a length less than 41 cms., twenty-seven are between 41 and 44 cms. in length, while 37 are closely grouped around the mean value, lying between 44 and 47 cms. Of the remainder, thirty-two lie between 47 and 50 cms.; only two exceed 50 cms. in length. The oblique length is constantly slightly less than the maximum length and shows a closely similar distribution.

Of the indices, the length circumference index and bicondylar index display a comparatively small range in variation and do not require detailed analysis. The platymeric and pilasteric indices on the other hand, both have a very wide range.

Martin (1928) classifies the Platymeric Index in four groups, viz.:

Hyperplatymeric	(x—74.9)
Platymeric	(75 —84.9)
Eurymeric	(85.0—99.9)
Stenomeric	100+

According to this classification 12% of this series are hyperplatymeric; 30% platymeric; 42% eurymeric and 16% stenomeric. There is thus a preponderance of non-platymeric over platymeric specimens.

However the classification of Bello y Rodriguez, cited by Martin, differs from the foregoing in setting the upper limit of platymeria at 80 instead of 85. This view is also taken by Cameron (1934). If this system is adopted then 76% of this series show no platymeria. Bello y Rodriguez further classifies the degrees of platymeria as very strong (below 65), well marked (65-75) and light (75-80). Of the platymeric specimens in this series, twelve specimens show light and 12 well-marked platymeria, none attaining to the "very strong" category.

The literature reveals no accepted classification of the Pilasteric Index. In this study it has been provisionally classified in four groups; below 100, 100-120, 120-140, and upwards of 140. Of these femora examined, 8.3% have an index below 100. By far the greatest number (64.6%) fall between 100 and 120; 26% are between 120 and 140, while only 1.1% exceed 140.

It may therefore he said that the male Zulu femur is generally characterised by the absence of platymeria and by a very moderate degree of pilastering.

I have to express my thanks to Professor R. A. Dart for the opportunity of undertaking this investigation. I also wish to thank Dr. L. H. Wells for his encouragement and helpful suggestions while the work was in progress.

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TABLE I. MEASUREMENTS OF MALE ZULU FEMORA.

Indices and Measurements.	Right side.			Left side.			Both sides.		
	Range.	Mean±S.E.	S.D.	Range.	Mean±S.E.	S.D.	Range.	Mean±S.E.	S.D.
Max. Length ...	40 —51	45·4 ±0·73	2·56	40 —51	45·66±0·71	2·51	40 —51	45·53±0·51	2·54
Oblique Length ...	39·5—50·5	45·18±0·7	2·5	39·5—50·5	45·5 ±0·67	2·4	39·5—50·5	45·34±0·49	2·47
Circum. at Mid Shaft	7·1—10·7	9·10±0·2	0·7	7·1—10·7	9·10±0·2	0·7	7·1—10·7	9·10±0·14	0·69
A.P. diam. below Less. Troch.	2·05—3·25	2·59±0·07	0·25	2·05—3·25	2·65±0·06	0·23	2·05—3·25	2·62±0·05	0·24
Trans. diam. below Less. Troch. ...	2·3 —3·7	3·02±0·08	0·3	2·3 —3·7	3·01±0·08	0·29	2·3 —3·7	3·01±0·06	0·29
A.P. diam. at mid Shaft	2·25—3·85	3·04±0·1	0·35	2·25—3·85	3·03±0·09	0·34	2·25—3·85	3·04±0·07	0·34
Trans. diam. at mid Shaft	2·05—3·15	2·67±0·07	0·25	2·05—3·15	2·68±0·06	0·23	2·05—3·15	2·68±0·05	0·24
Bicondylar Breadth	6·9—9·1	8·00±0·13	0·45	7·1—8·9	7·98±0·13	0·45	6·9 —9·1	8·0 ±0·09	0·45
Length Circumference Index	17·0—22·6	20·6 ±0·28	1·00	17·0—23·4	19·8 ±0·33	1·19	17·0—23·4	19·93±0·23	1·15
Bicondylar Index ...	15·4—19·8	17·62±0·22	0·77	15·4—18·6	17·42±0·20	0·70	15·4—19·8	17·52±0·14	0·72
Platymeric Index ...	67—122	86·0 ±2·6	9·25	67—122	89·0±2·90	10·25	67—122	87·5 ±2·04	10·20
Pilasteric Index ...	81—150	113·7 ±3·08	10·5	81—150	113·2 ±2·66	9·1	81·150	113·4 ±2·02	9·87

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REPORT ON A SKELETON FROM THE FISH HOEK CAVE

BY

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Read 30th June, 1941.

Through the kindness of the late Mr. Peers, senior, of Fish Hoek, the Department recently obtained two practically complete " Strandloper " skeletons. They form part of a group of individuals buried in a superficial stratum of the Fish Hoek or Skildergat Cave. Public attention has been directed to this locality by the action of the Fish Hoek Municipality in taking steps towards its preservation as a National Monument. These bony remains were found in a sea shell stratum some 4-5 feet below the surface (Keith, 1931). The depth and type of stratum correspond closely to the conditions described for the Oakhurst Shelter remains. These latter Professor Drennan (1938) classifies as a group which must have occupied the shelter for " quite a considerable time prior to the European occupation of the country." The origin and affinities of the " Strandloper " people are still in doubt, and for this reason I have thought it worth while to analyse these skeletal remains, although they are not necessarily of any great antiquity.

The skeletons are both female, one adult and a smaller adolescent one. From a study of the epiphyses the age of the younger individual can be given with fair accuracy as between 18 and 20 years. Adolescent bones are not suitable for anthropometric measurements because the recognized formulae and tables have been worked out on adult bones. The measurements of the skull and long bones which follow, are those of the adult female skeleton.

Measurements of cranium: Maximum length 183 mm. Maximum breadth 132 mm. Cephalic index 72. Basion-bregma height 130 mm. Cranial capacity (by Turner's method) 1335 cc.

Measurements of face: Maximum bizygomatic diameter 121 mm. Nasion-prosthion 66 mm. Basion-prosthion 93 mm. Basion-nasion 97 mm.

Measurements of mandible: Maximum length 106 mm. Maximum breadth 114 mm. Index of mandible 93.

For comparison I give some of the average measurements from Tables IV and V in Professor Drennan's analysis of the Oakhurst Shelter remains (1938).

TABLE I.

	Hottentot Type			Bushman Type	
	Males (Drennan)	Females (Hrdlicka)	Females (Broom)	Males (Drennan)	Females (Hrdlicka)
Cranium					
Maximum length ...	192	176	189	178	174
Maximum breadth ...	140	135	129	138	131
Basion-bregma height	132	123	132	125	123
Face					
Mx. bizyg. diameter	130	125	125	124	119
Nasion-prosthion ...	73	66	67	65	58
Basion-prosthion ...	102	93	98	96	94
Basion-nasion ...	102	94	102	97	95
Mandible					
Maximum length ...	107	—	—	97	—
Maximum breadth ...	114	—	—	110	—

The skull measurements of this particular "Strandloper" skeleton suggest the Hottentot rather than the Bushman type, a fact which is obvious as soon as the actual measurements are compared with those in Table I. The cranium figures come about halfway between the male and female Hottentot averages. The face measurements come nearest to the female Hottentot series, especially the first of the two female columns, some of the figures being identical, e.g. nasion-prosthion and basion-prosthion. The mandible is of the strong, massive Hottentot type, its maximum measurements being practically the same as those of the male Hottentot averages in the table.

This is of interest because it is sometimes claimed that in the true Hottentot there are marked differences between male and female skulls, a characteristic also noted in the Oakhurst tribe (Drennan, 1938). We are either dealing with an exceptionally large-headed female "Strandloper," or we must class this individual among the Broom Hottentot females with relatively enormous heads. These latter are regarded by Professor Drennan as the Boscopoid type or precursor of the true Hottentot (1938). It is not known whether the marked sexual differences also occur in this pre-Hottentot race. The vault of the Hottentot skull, as measured by the basion-bregma dimension, is higher than that of the Bushman. The most valuable index to bring out the difference between the two races is agreed to be the breadth-height index (Broom, 1923 and Drennan, 1938).

In the skull under discussion the *breadth-height index* (130/132) is 98.5, a higher figure for this index than any given for Hottentot male or female skulls by other observers, except Broom (1923). The *cranial capacity* of the skull is 1335 cc., a figure which also indicates a Hottentot rather than a Bushman affinity, the average Bushman cranial capacity (male and female) being 1250 cc. The average cranial capacity of the Oakhurst tribe is 1307 cc.

Length of the limb bones (in mm.): Humerus R 281, L 273. Radius R 222, L 220. Ulna R 237, L 233. Femur R 404, L 403. Tibia R 345, L343. Fibula R 339, L 338.

For comparison I have made use of a table in the Oakhurst Shelter analysis (Drennan, 1938).

TABLE II.

	Oakhurst Tribe (♀) (Drennan)	Hottentots (♂ and ♀) (Vermooten)	Bushman (♀) (Slome)
Humerus	280	308	272
Radius	220	242	203
Femur	400	433	391
Tibia	335	375	321

The measurements of the humerus, radius, femur and tibia in this skeleton show most resemblance to the Oakhurst tribe figures, in fact a remarkable similarity except for a tibia which is slightly longer. The Hottentot figures in the Vermooten series are not strictly comparable because they include male bones. Except for the relatively short humerus, the limb bones are in each instance decidedly longer than the female Bushman averages (Slome). The measurements of the limb bones, although not to the same extent, re-inforce the conclusion arrived at after examining the skull, viz., that this female Strandloper skeleton must be considered as belonging to the Hottentot, rather than to the Bushman stock.

Determination of Living Stature.

In the completely articulated skeleton we have an additional method available for estimating the stature of the living individual. There can only be very few completely articulated "Strandloper" skeletons in existence (see figure). It therefore seemed appropriate to use this special opportunity in order to make a comparison between two methods of estimating stature.

The ordinary method is the well-known one of measuring the various long bones, and then obtaining the stature by the use of recognized anthropological formulae or tables. The length of the limb bones is determined by the use of the osteometric board, using the oblique position for the femur. The right and left bones are measured separately and the average of the two figures is taken. As we are dealing with macerated bones, 2 mm. must be added to each figure to allow for the articular cartilage. The length of the cadaver is then usually obtained by means of the recognized Manouvrier's tables (Martin, 1928). Different tables are used for the two sexes. A further adjustment is needed to calculate the stature of the living from the cadaver length. One has to subtract 1.26 cm. for a man and 2 cm. for a woman (Pearson, 1899).

The additional method available in this case consisted in measuring the height of the articulated skeleton and then making various adjustments which have to do with the vertebral column and the soft parts. The height of the articulated skeleton from the heel to the top of the cranium is 144 cm. The vertebrae are macerated and allowance must be made for the absence of the intervertebral discs. The latter constitute about one-fourth of the length of the vertebral column, exclusive of the first two vertebrae (Gray, 1938). The length of the vertebral column is 42 cm. In mounting the skeleton a limited amount of spacing had been allowed between the vertebrae. I therefore decided to add only two-thirds of the full correction, i.e. an addition of 7 cm. instead of 10.5 cm. In order to obtain the cadaver length from the articulated skeleton, one has to allow for the soft parts. The difference is variously estimated. According to Pearson (1899) between 8 and 3.5 cm. have to be added, say 6 cm. This gives 144+7+6=157 cm. As before, two centimetres must be deducted to get a figure representing the living stature. The results of both calculations are set out below.

TABLE III.

Length in mm. ...	Humerus 277	Radius 221	Ulna 235	Femur 404	Tibia 344	Fibula 339
Calculated height from Manouvrier's Tables (in cm.)	148·8	158·5	157·5	153·7	158·2	158·2
	Mean of the six measurements = 156 less 2 = 154 cm.					
Calculated height from articulated skeleton (in cm.)	144+7+6=157 less 2=155 cm.					

We may note that the femur length gives the nearest approximation to the actual height, as determined by the mean of the six measurements or by direct calculation from the skeleton height. This is in accordance with Pearson's statement in an article on stature reconstruction (1899); the *femur* as a single bone is more reliable than any of the others. The *tibia* is the next in reliability to predict stature from in the case of women, the *humerus* in the case of men. The *radius* by itself is said to be the least reliable of the long bones in both sexes. Not all of these statements are confirmed in the present instance, but no great importance can be attached to this fact, as we are dealing with a single skeleton.

The average Bushman height (♀) is given by Slome (1929) as 147 cm., and the average height of Hottentot women as 149 cm. The present " Strandloper " female was considerably taller than either. The closest resemblance as regards stature is once more to the females of the Oakhurst tribe with a height of 153 cm. (average of four females).

DISCUSSION.

Stow (1905) believed that the Bushmen were the aborigines of South Africa and that the Hottentots came from the North and encroached on the Bushmen's territory. He traces the migration of the Hottentots from Central Africa along the West Coast to the Cape Peninsula, and then along the South Coast. The Bushmen were displaced from the Coastal Belt and driven inland. The navigators of the 15th and 16th centuries first came into contact with the Hottentot tribes who were for a long time considered to be the aborigines of the country.

In the early records of the Dutch settlers in the 17th century there is a great confusion of names whenever native tribes are spoken of. Apart from the name Hottentots, they were sometimes termed the Watermans, sometimes the Strandlopers (beachrangers). The predatory habits of the inland Bushmen were well known but it was supposed that they were merely another Hottentot clan (Theal, 1888).

Shrubsall (1907) has complicated the problem by insisting on very distinct racial characteristics of the so-called Strandlopers who are said to be a purer group than the Bushmen, and to be distinct from the Hottentots. He admits that he had only a small amount of material and that the influence of chance selection cannot be quite excluded. In other words he accepted the classification of the crania which were submitted to him labelled as either Strandloper (12), Bushmen (79) or Hottentot (30), and established his data on those premises. If the original grouping cannot be relied upon, the value of Shrubsall's conclusions is considerably lessened.

Broom (1923) points out the difficulty in which Shrubsall became involved and states that the Strandlopers are really not a race and the name ought never to have been used. " All along the coast of South Africa are to be found kitchen-middens of shells formed by natives who had lived on the shores and fed mainly on shell-fish, and near these middens graves of natives are very often found." In this sentence Broom carefully uses the term " natives " without identifying them with any special group.

The discovery of Hottentot types in the Oakhurst Shelter at a relatively superficial level, at deeper levels in the Matjes River Cave (Keith, 1933), and now of these individuals in the Fish Hoek Cave raises the question as to the exact racial origin of these coast dwellers. The true Bushman is culturally palaeolithic (Drennan, 1937), whilst the Hottentot culture is predominently neolithic. Living as they did contemporaneously and sometimes in close proximity, it is obvious that some intermingling of the two races and of their distinctive cultures must have occurred in the coastal area. No doubt the Bushmen in their hunting expeditions occupied some of the coastal caves from time to time. But the shell-middens which are such a feature of these shelters and the tidal fish traps (viskraals) recently discovered in their close vicinity (Goodwin, 1941) suggest a neolithic element which so far has been associated with the Hottentot type. The close resemblance between the South African coastal culture and the Danish kitchen-midden culture, as described by Tyler (1921), has been stressed by Drennan (1937). If the inhabitants of these caves are accepted as being Hottentot, instead of being linked with the Bushman, as has been done up to the present, it will no longer be necessary to recognize neolithic elements in the Bushman culture.

Schapera (1930) takes the view that the Hottentots and the Bushmen are so much alike in physical characters and so distinct in appearance from the other inhabitants of South Africa, that one must look upon them as closely allied in race. The Hottentots, according to Schapera, were originally a Bushman people who migrated South at a very much later period, perhaps more than a thousand years after the Bushman migration. During this time interval the physical characters of the Hottentots became changed by admixture with some other racial group. Thus the Hottentots became a taller people with relatively larger heads and prevalently dolicocephalic. Shrubsall (1907) who worked only on skeletal material believed that the admixture was with Bantu stock. This view was then abandoned in favour of the suggestion that an admixture occurred with the light-skinned Hamitic stock, probably with the addition of a negro element (Schapera, 1930). The fact that the racially pure Hottentots now differ only very slightly amongst themselves suggested that the intermixture which gave rise to them was of very long standing, and hence probably originated before they came into South Africa.

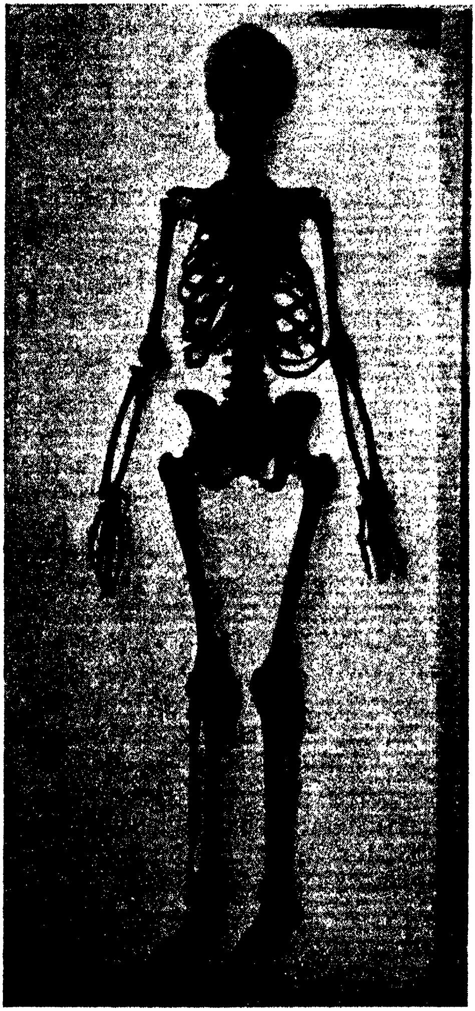
The view that the Hottentots migrated into South Africa within comparatively recent times is not supported by the archaeological evidence. One has only to refer to the Matjes River Cave findings (Keith, 1933). The skulls discovered in this shelter at considerable depths, were pronounced by Sir Arthur Keith as Hottentot in type, pointing to the presence of a Hottentot-like people in this part of the Cape Province at a much earlier period than is suggested by the " migration theory." In fact Keith speaks of a prehistoric type of South African which came into being south of the Zambesi, and in the course of time local races, such as Bushmen and Hottentots, have arisen.

The majority of physical anthropologists have no hesitation in clearly defining and separating these racial groups. A pure Hottentot skull (including " Strandloper " material) is as different from the pure Bushman skull on the one side, as it is from the Bantu skull on the other side. As regards the term " Strandloper " this should no longer be used to denote a racial unit, as Broom already insisted nearly twenty years ago. Although the so-called Strandloper may occasionally present a Bushman type, the majority are proving to be Hottentots. They should henceforth be looked upon as a subdivision of the Hottentot group with a propensity to living along the sea shore, and only loosely linked with the Bushman.

SUMMARY.

The author gives an anthropometric report on a Strandloper skeleton discovered in a superficial sea shell stratum in the Fish Hoek Cave. The measurements of the skull and

of the long bones clearly point to a Hottentot affinity, with a close approximation to the skeletal material from a similar sea coast shelter near Oakhurst. The determination of living stature is discussed and the two methods available in the case of an articulated skeleton are described and contrasted. Further, the author reviews the rival theories on Bushman and Hottentot origin and interrelation, and points out the confusion which arises by using the term "Strandloper" in a racial sense.



Completely articulated adult female Strandloper skeleton from Fish Hoek or Skildergat Cave, presented to the Department of Anatomy, University of Cape Town by the late Mr. Peers, Senr.

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THE BAYVILLE "AUSTRALOID" SKELETON

BY

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With 1 Table.

Read 30th June, 1941.

In his classic paper on the craniology of the yellow-skinned races of South Africa, Dr. Robert Broom (1923) noted in his "Korana" group

> "clear traces of an Australoid race, or at least a race with well-developed supra-orbital ridges."

Discussing this question further he says:

> "So far I only know of one skull—and this probably of no very great antiquity—which may be regarded as coming near to that of the supposed Australoid of the south. The skull comes from Bayville near Port Elizabeth. It is not at all fossilised but is evidently of considerable age, and it differs from any other skull that has been found in South Africa, so far as I am aware, in the great development of the supra-orbital ridges."

He gives a figure of this skull with the following remarks:

> ". . . the skull resembles in general shape that of the Koranas, and rather less that of some Bantus, and differs almost entirely from the Bushman type. The brow is well developed and not unlike that of some Bantus, but the presence of large supraorbital ridges gives it a very different appearance. These ridges are about as well developed as in the average male Australian, but the forehead is better developed in the South African skull. The parietal region differs from that of both the Bantu and the Australian in being low, and in this agrees with the Korana and the Bushman. As will be seen by the measurements given, it agrees closely with the average Korana. The face is short, the nose broad and the orbits low.
>
> The cranial bones are of great thickness. The greater part of the frontal bone is 11 mm. and much of the parietal about 8 mm. thick."

Although the Bayville skull is thus the " type " of the supposed Australoid group of South African crania, no further description of it has been given by Dr. Broom or any other worker. My attention having lately been directed to the problem of the " Australoid " type in South Africa, Dr. Broom very generously placed the Bayville remains at my disposal, with the suggestion that I should prepare a more detailed account of this specimen than has hitherto been available.

DESCRIPTION.

The remains comprise the greater part of the skull and mandible together with large portions of the remainder of the skeleton. From the fragments of the pelvic girdle it is clear that the bones are those of a male subject. That the individual was of advanced age is shown by the almost complete obliteration of the sutures of the vault, the external part of the lambdoid suture alone remaining visible, also by the extremely worn state of the teeth.

Skull. This lacks portions of both parietals and of the sphenoid, and the whole of the left temporal and zygomatic bones. There are, however, no important features which are not determinable. Dr. Broom's measurements of the specimen and those taken by myself are given in Table I. It will be seen that almost all of our measurements agree within the limits of instrumental accuracy, except for the nasal height and the palatal length, in which cases there is clearly a difference in our technique of measurement.

As the table shows, the skull is of remarkable length, relatively narrow (hyperdolichocephalic) and low-vaulted (chamaecephalic). All the bones of the vault are of an infantile contour, so that the skull falls into the chamae-ovoid category. The cranial capacity cannot be directly estimated, but various methods of calculation give results ranging from 1520 to 1620 ccs.; it is thus definitely megacephalic.

When viewed from above the skull is seen to be phaenozygous; the frontal region is of moderate breadth. The frontal bone shows a distinct median ridge, narrow on the forehead, but widening as it passes on to the vault, where it is defined by a shallow depression laterally. This depression is continued backwards across the coronal suture on to the anterior portion of the parietal bone. There is no median groove or depression in the posterior parietal region.

In a lateral view the glabella and superciliary eminences have a bold projection above the root of the nose, which gives to this region a character quite unusual among South African native crania. The prominence of the superciliaries is enhanced by a shallow transverse ophryonic groove; this groove is interrupted in the middle line by the median ridge. As a whole the forehead is low and somewhat receding, and passes by a very gradual curve into the vault. So far as can be determined, no point on the vault is higher than the bregma. There is a slight postcoronal groove, resulting from the confluence in the mid-line of the bilateral depressions noted on the superior surface. The parieto-occipital region descends by a gentle curve into the occiput. A well-defined torus occipitalis limits the nuchal surface posteriorly. In front of this ridge there is a shallow transverse groove, the remainder of the nuchal surface being slightly convex.

The mastoid process is of moderate size and projection; nevertheless it leaves exposed the posterior extension of the digastric fossa. There is no ridge on the outer surface of the process corresponding to the attachment of the sterno-mastoid muscle. The supramastoid groove is narrow, but relatively deep and sharply defined. This groove is clearly an independent feature of the skull, owing nothing to the sterno-mastoid ridge or to the supra-mastoid crest, which is very indistinct. though it can be seen to curve sharply upwards from the posterior border of the external auditory meatus .The tympanic plate is very thin, and the posterior root of the zygomatic arch rounded and of moderate stoutness. The parieto-squamous suture has a very low convexity, its highest point rising very little above the level of pterion. There is a slight temporo-sphenoidal eminence, but no inferior frontal eminence apart from the general lateral convexity of the frontal bone. Across this bone the anterior portion of the temporal line, which is rough but not markedly projecting, descends steeply, to pass by a wide curve into the external angular process. The face, in a lateral view, is clearly orthognathous.

Viewed from the front, the braincase forms a low dome, its rounded contour being broken by the shallow depressions on either side of the broad median ridge. The salient glabellar region is very much encroached upon by the medial ends of the large, massive superciliary eminences. These eminences merge with the medial portion of the superior orbital margin, and extend laterally as far as the middle of this margin. They are, however, sharply defined by a groove from the lateral portion of the margin, the supraorbital region being thus of Cunningham's second type. This lateral portion of the margin is thick and rounded, expanding laterally into a distinct tubercle which forms the extremity of the external angular process. The area of the trigonum supraorbitale is slightly excavated, and the external angular process forms a broad truncated triangle with a bold lateral projection. Large supraorbital foramina open into the groove between the superciliary eminence and the lateral supraorbital margin. There are a number of small secondary foramina, but no grooves for the branches of the supraorbital nerve on the tabular part of the frontal bone.

As Dr. Broom has pointed out, the face is short and broad. In correlation with this, the orbits are low; they are rectangular in outline, and their long axes slope downwards and outwards. The margins of the orbits are thick, and at the infero-lateral angle the margin is flattened to produce a conspicuous "orbital shelf" of Keith. As is usually the case when this feature is present, the infra-orbital process of the malar bone forms a sharp angle with the external surface of the body of this bone, which is directed laterally and slightly upwards.

The infra-orbital region, which is depressed beneath the overhanging glabella, is broad and nearly flat, the broad nasal processes of the maxillae facing anteriorly and slightly laterally, while the nasal bones are very narrow at their root and slightly arched. Since the lower portion of the nasal bones is missing, the form of the nasal aperture cannot be determined. It is however of very considerable breadth. The inferior margin of the nasal gutter is very indefinite, but a nasal gutter is faintly indicated; the nasal spine is short but massive. Although the infra-nasal alveolus is much distorted by periodontal abscesses, it must have been relatively short. There is no definite canine fossa, and only very slight hollowing of the infra-orbital process of the maxilla.

Although the dental arcade and palate are somewhat deformed by abscesses and the loss of teeth, they are clearly relatively short and broad. The dental arcade is U-shaped; the palate is shallow, shelving in its anterior portion, and with few irregularities of its surface. Those teeth which remain are very heavily worn. A basal view of the skull also shows the glenoid fossa to be broad and shallow, with a flattened articular and indistinct post-glenoid tubercle. The squamo-tympanic fissure is conspicuous in the floor of the fossa, and the articular surface extends backwards on to the tympanic plate. In shape the foramen magnum is a long narrow ellipse, slightly encroached upon in its anterior portion by the occipital condyles. These are elongate, and their flattened articular surfaces face as much laterally as downwards.

Mandible. This bone is fairly large, but not at all massive or rugged in build. Its ascending ramus is relatively short but narrow, with a shallow sigmoid notch and low blunt coronoid process. The anterior border of the ramus stands well away from the hinder end of the molar alveolus, a well-defined groove intervening between them. This border can be traced downwards into a prominent trihedral eminence on the lateral aspect of the body in the molar region. Owing to the presence of this eminence the molar portion of the body is thick in proportion to its height.

The height of the body increases slightly from the molar region to the symphysis, its inferior border being somewhat convex. There is a slightly projecting, well-defined triangular mental protuberance, flanked by mental tubercles which are blunt and not at all prominent. The incisive alveolus is short and does not project. On the internal aspect of the symphysis there is a large " supra-genial " pit which contains the attachment of the genio-glossus muscles. Its lower border is formed by a prominent transverse ridge which intervenes between the attachments of the genio-glossus and genio-hyoid muscles. No torus mandibularis is identifiable. The mylohyoid ridge on the internal aspect of the body pursues an unusual sinuous course; Dr. G. W. H. Schepers has pointed out to me that this peculiarity is also to be seen in the mandible of the Cape Flats skull.

Other Skeletal parts. Those *vertebrae* which have survived are large, rugged, and much distorted by spondylitis. The atlas has a thick, notably asymmetrical posterior arch, and short massive transverse processes in which the transverse foramen appears compressed against the lateral mass. In the fifth and sixth cervical vertebrae the spinous processes are massive, straight and non-bifurcate.

The right *humerus*, which is complete, has a length of 32.2 cms.; the left is incomplete and much more slender than the right. Both bones display a lateral bowing at the level of the deltoid tuberosity, and a forward concavity of the lower portion of the shaft. There is a wide angle between the axes of the superior and inferior extremities. The distal articular surface has the same peculiar conformation as was described by Galloway (1937) in the humerus of the skeleton M.5 from Mapungubwe; the medial epicondyle is not particularly prominent. A considerable supra-condylar foramen is present in the right humerus. Since this foramen is considered to be more often present on the left side than on the right, and in females than in males, its presence in the right side in this undoubtedly male specimen is worthy of remark.

Of the *innominate bone* only portions of the ischium and pubis are preserved; these are sufficient to establish the sex of the individual. The most noteworthy feature of these fragments is the great size of the pubic tubercle, which forms a massive rounded elevation more than a centimetre in diameter.

The maximum length of the right *femur* is 44.2 cm., and of the left 45.0 cm., the corresponding lengths in the oblique position being 44.1 and 44.7 cm. There is a strongly marked " empreinte " on the anterior aspect of the short stout neck of the femur. In its upper portion the shaft displays considerable antero-posterior flattening, giving a platymeric index of 75.0. The gluteal tuberosity forms an elongated rugged prominence, flanked by a narrow hypotrochanteric fossa. In the middle portion of the shaft the linea aspera is very prominent, the pilastric index being 124.0; the lips of this long ridge are boldly defined. The medial epicondylic line on the other hand is almost imperceptible.

There is practically no difference in length between the two *tibiae* (right 38.2 cm., left 38.1 cm.). The shaft of this bone is considerably flattened medio-laterally, giving an index of 63.9. Its anterior margin is rounded and indistinct; there is a definite squatting facet at the inferior end.

Calculation from the lengths of the intact long bones gives estimates of the stature ranging from 1638 mm. (5 ft. 4½ ins.) to 1694 mm. (5 ft. 6½ ins.) with a mean value of 1662 mm. (5 ft. 5½ ins.). This individual was thus of moderate stature, and by no means dwarfish. From these calculations it is also evident that the femur is long in proportion to the humerus, and the tibia long in proportion to the femur.

DISCUSSION.

From the foregoing description it is apparent that the Bayville skeleton is in its salient features widely different from that of the South African Negro. It is equally sharply differentiated from the Bush type properly speaking, being considerably larger and more robust in build. This specimen therefore takes its place among the large-headed non-Negro and non-Bush types of South Africa. Even among these, however, it is given a very special position by the massiveness and prominence of the supra-orbital region. This region differs not only from that of the Negro and Bush types, but also from those of the Boskop, Springbok Flats, Fish-Hoek and Matjes River fossils; it even exceeds in robustness and salience that of the Cape Flats skull, though it does not attain the development seen in Florisbad Man. The supra-orbital region of this skull is, in fact, much more nearly comparable with those of many Australian crania than with any recognised South African type. From this point of view the application of the term " Australoid " to the Bayville skull appears justified, so long as it is appreciated that this usage is purely descriptive and does not postulate any special and narrow affinity between this individual and the Australian type. As Galloway (1937) has pointed out, if the Bayville or Cape Flats skull be compared with that of the typical Australian, the characters of which have been defined by Krogman (1932), the resemblance is almost entirely in the development of the supra-orbital region.

While Dr. Broom regards the " Australoid " type as constituting a distinct element in South African physical anthropology, Galloway (1937) has challenged this view, maintaining that " in skulls such as Cape Flats and the other ' Australoid ' South African types we have a usual variant of the Boskop type." (The name Boskop is used by Galloway to include all massive large-skulled pre-Negro remains.) To some extent the difference is one of emphasis: Broom differentiates a series of types without considering whether they may not have a by no means remote common ancestor; Galloway believing that he can recognise the evidence for this common ancestry tends to confound the descendant types in one.

Dr. Broom has regarded the " Australoid " characters of this specimen as superimposed by hybridisation upon the physical type which he distinguishes as " Korana." It is indeed very difficult to isolate any characters in this individual other than the supra-orbital development which can be considered as proper to the "Australoid" type. The capacious, elongated, low-vaulted and ovoid braincase is in Dr. Broom's conception diagnostic of the "Korana" type. Such a type may need very possibly to be differentiated from other massive and large-headed pre-Negro crania. It is to Dr. Broom's selection of the name "Korana" that exception may be taken. This name belongs of right to the historic group of people inhabiting the Vaal-Orange basin, who have been studied ethnologically by Professor L. F. Maingard (1932) and by Engelbrechi (1936). The extension of the name to any other people on the basis of a physical character which is not yet proven to belong to the majority of the historic Koranas (J. F. Maingard 1932) appears highly undesirable. It may well be that the type distinguished by Dr. Broom is valid but if so it should be given a name free from ethnological implications.

TABLE I.

MEASUREMENTS AND INDICES OF THE BAYVILLE SKULL.

Measurement.	Broom.	Wells.
Max. Cranial Length	201 mm.	201 mm.
Max. Cranial Breadth	136 mm.	138 mm ?
Basi-bregmatic Height	137 mm.	137 mm.
Auriculo-bregmatic Height	—	119 mm.
Least Frontal Breadth	—	97 mm.
External Biorbital Breadth	—	111 mm.
Internal Biorbital Breadth	100 mm. ?	100 mm. ?
Bizygomatic Breadth	—	132 mm. ?
Naso-alveolar Height	62 mm.	62 mm.
Orbital Breadth	41 mm.	42 mm.
Orbital Height	30 mm.	31 mm.
Bidacryonic Breadth	26 mm. ?	27 mm. ?
Nasal Height	45 mm.	47 mm.
Nasal Breadth	28 mm.	28 mm.
Basi-nasal Length	104 mm.	104 mm.
Basi-alveolar Length	96 mm.	96 mm.
Maxillo-alveolar Length	—	51 mm.
Maxillo-alveolar Breadth	—	65 mm. ?
Palatal Length	50 mm.	44 mm.
Palatal Breadth	39 mm. ?	39 mm. ?
Cranial Index	67·7	68·7 (?)
Altitudinal Index	68·0	68·2
Auricular Height Index	—	59·2
Breadth-height Index	100·7	99·3 (?)
Fronto-parietal Index	—	70·3 (?)
Fronto-biorbital Index	—	87·4
Upper Facial Index	—	47·0 (?)
Orbital Index	(73·2)	73·8
Interorbital Index	—	24·3 (?)
Nasal Index	62·2	59·6
Gnathic Index	(92·3)	92·3
Maxillo-alveolar Index	—	127·5 (?)
Palatal Index	—	88·6 (?)

On behalf of this Department I have to express our gratitude to Dr. Robert Broom for the loan of this valuable specimen. I personally am indebted to Professor R. A. Dart for the suggestion of this line of investigation.

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UNDERGROUND STRUCTURES IN CAVES OF THE SOUTHERN TRANSVAAL

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In the Gatsrand hills some twenty miles north-north-east of Potchefstroom and six or seven miles north-east of Frederikstad, stone hut-foundations occur on the farm Kleinfontein 36. These remains surround the entrance to a fairly extensive underground cavern in which unusual stone-and-daub structures are preserved. The cave was first explored in 1934 by the Rev. E. Patterson and Mr. L. Brumage of Potchefstroom. In November, 1940, it was examined by the writers and Mr. H. B. S. Cooke, under the guidance of Mr. Brumage.

Structures somewhat similar in character to those in the Kleinfontein cave exist in a cave on the farm Zeekoeifontein 21 near Lindequesdrift in the Vereeniging district, some twenty-five miles to the south-east. This site was visited by a party from the Department of Anatomy, University of the Witwatersrand, in March, 1934.

THE KLEINFONTEIN (GATSRAND) SITE.

This site lies towards the north-west corner of the farm Kleinfontein 36, on a slight rise separated from the Gatsrand hills by a wide shallow valley. The surface ruins are on a fairly level area, and the cave entrance lies in a slight hollow only a little below the general plain; its presence thus remains unsuspected until one approaches to within a few yards of it (Fig. 1).

SURFACE STRUCTURES. The stone constructions surrounding the entrance to the cave can be divided into three categories: "hut" circles, mounds and enclosure walls.

"HUT" CIRCLES: These are rings with a diameter of 10-12 feet, formed of flat slabs set on edge (Fig. 2), the thickness of the stone-work being six to eight inches. Each ring has an entrance gap from 18 to 28 inches in width, the average being about 24 inches. No definite orientation of these gaps could be observed, and there is no trace of a stone sill to the entrance. The floor within is of earth and appears to have been artificially levelled; no indications of stone paving were observed.

MOUNDS: These are small, roughly circular accumulations of stones approximately 3-4 feet in diameter and up to a foot in maximum height. The stones composing them are irregular blocks rather than slabs, and do not present any definite arrangement.

ENCLOSURE WALLS: These are some 18 inches to 2 feet in thickness, and composed of a foundation of two rows of large blocks with a core and superstructure of smaller stones. Most examples are broken down almost to their foundations. Some portions are better preserved, standing to a height of two or three feet, but these well-preserved walls have in some cases the appearance of being more recent than the other structures. An opening in one of the collapsed walls is about two feet in width, and flanked by large blocks (Fig. 3). The floor of this entrance and the part of the enclosure just within it, have the appearance of being roughly paved with slabs.

Some of these enclosure walls form definite circles with a diameter of 20-30 feet. Others seem to embrace larger areas, but their plan cannot be clearly made out. No definite plan of the whole area of constructions could be determined, though the "hut" circles appear immediately to surround the cave entrance, the enclosure walls being rather more distant. The mounds are scattered among the "hut" circles, these two seemingly constituting a system distinct from that of the enclosure walls. There was no evidence of enclosure walls encircling single huts or even groups of huts.

THE CAVE. We are indebted to Mr. H. B. S. Cooke of the Department of Geology, University of the Witwatersrand, for the following observations:

The entrance to the cavern takes the form of a wedge-shaped fissure (Fig. 4), some twelve or thirteen feet in length and two to five feet in width and lies with its long axis roughly north-west—south-east. The large central cave into which this opening leads is elongated in the same general direction and on all but the north-east side the cave roof sharply undercuts the entrance and takes somewhat the form of an oblique cone. The north-eastern wall drops almost vertically from the entrance and a platform jutting out from it about twelve feet below the surface provides a base upon which a ladder can be rested. From this platform a conical mound of talus, probably covering a more solid base, stretches down to the floor of the cave some thirty to forty feet below the surface. In places this mound meets the sloping roof, but at various points the roof becomes less steep and other caverns lead off from the central one. These secondary caverns are for the most part not high and are very irregular in form, varying from quite wide areas with domed roofs to narrow low passages. The average height is less than six feet and the whole arrangement is typical of the erratic workings of underground water.

The caves are developed in the transitional zone between the Dolomite and the Pretoria Series and the beds have a shallow southerly dip of two or three degrees towards the Gatsrand hills. These hills are built up of Pretoria sediments and the chert zone of the Dolomite forms the slight eminence on whose southern slopes the site occurs. The exposures in the walls and roof of the cave show mainly the typical bedded soft quartzite and shale of the transitional zone, with intercalated dolomite layers and a lower dolomite containing numerous chert pebbles. On the surface the outcrops are entirely of reddish quartzite and it appears most probable that the caves owe their origin to underground waters pursuing the easy path of erosion between this harder quartzite and the cherty dolomite below. The caves are for the most part *not* developed in the dolomite itself, and in this respect are a little unusual. The walls and roof are damp, though there is little dripping water, and at the end of a long narrow descending passage on the southern side there is a pool of apparently permanent water which seems to have been used by the occupants of the cave. There are no other visible entrances in the area examined, and the secondary caves, in which all the constructions occur, receive practically no natural illumination.

CONSTRUCTIONS IN THE CAVE. The principal structures are small walled enclosures (Fig. 5), of which it is estimated that there are at least fifty in various parts of the cave. These enclosures are built singly or in groups, and almost

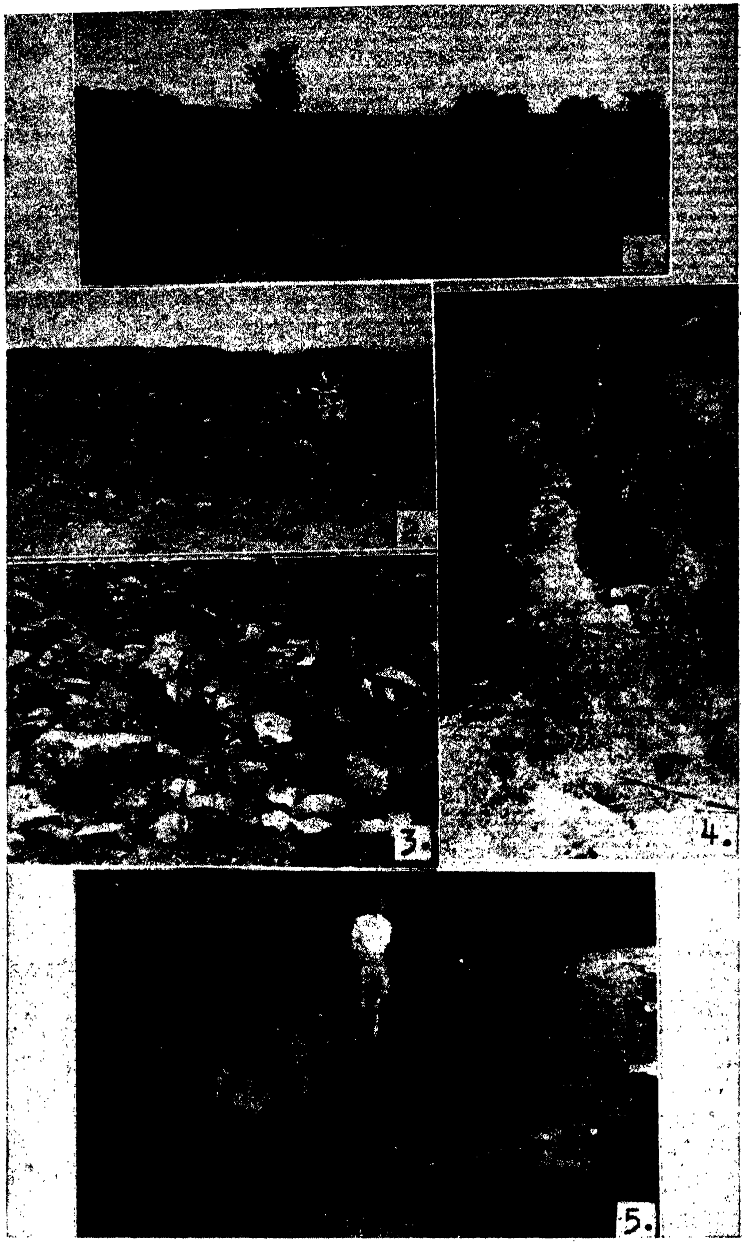


Plate 1. (1) View part of Gatsrand site, showing surface structures and position of cave entrance.
(2) Typical "hut" circle, Gatsrand site.
(3) Part of enclosure wall with entrance, Gatsrand site.
(4) Entrance to cave, Gatsrand site.
(5) Typical constructions in a lateral chamber of the cave, Gatsrand site.

invariably adjoining the side wall of the cave, so that in the majority of cases the wall forms part of the periphery of the enclosure.

Many of these enclosures, especially those of the smallest diameter, are of a fairly regular circular plan, while others are distinctly ellipsoidal. In some cases, however, an irregular plan with one or more angles is found. This may result from several causes: on the one hand, the cave wall may form a flattened segment of the perimeter, from which the built walls spring at a definite angle; in other cases, an enclosure has been contrived in the interval between two others, so that its sides are in part curved inwards.

These enclosures vary considerably in diameter, but it is doubtful whether the largest internal measurement of any specimen exceeds ten feet. Six to eight feet appears to be the usual measurement, while in several cases the diameter is not more than five feet.

The built walls of the enclosures vary considerably in height. Some well-preserved examples are not more than 1 ft. 6 ins. high, others as much as 3 ft. 6 ins.; the usual height, however, is about 2 ft. or 2 ft. 6 ins. In the more open parts of the cave the walls thus fall far short of the roof. There are, however, examples built in cavities where the roof is not more than four feet from the floor, and in these the walls rise nearly to roof level, but even here no case was observed in which the walls have been carried up to make contact with the roof.

At their base the walls have a thickness of about 8-10 ins., but they taper considerably as they rise, so that the thickness at the top is not more than 4-6 ins. The tops of the walls are flat. No trace of any form of roofing supported upon these walls has been observed. Each enclosure has a single narrow entrance, measuring 10-15 ins. at the base, and widening with the taper of the walls to measure 15-18 ins. at the top.

The built walls consist of a core of stones, generally flat slabs set on edge as in the 'hut" circles above ground, packed in clay and covered with a thick clay coating. In some cases the surface has been carefully smoothed, in others it is left rough with the finger-marks of the builders. Where the cave wall forms part of the perimeter of the enclosure, it has been faced with clay to the height of the walls, in some cases so thickly as to form a definite ledge at the top.

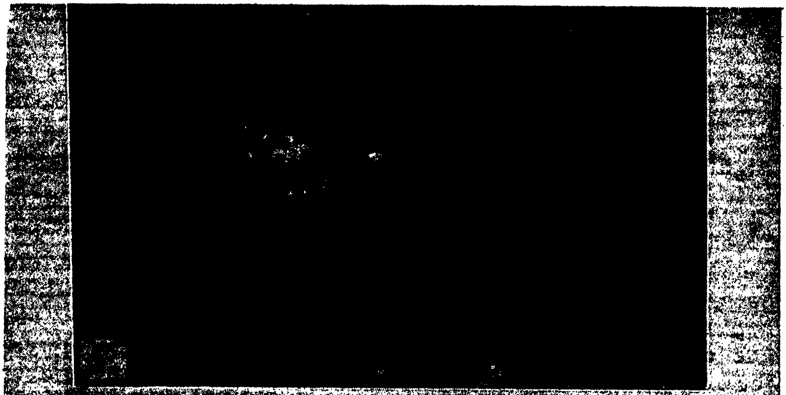
In most cases the floors of these enclosures appear to be of earth or clay. Excavation however has revealed a stone paving in some cases. A few specimens display a clay bench or dais, a few inches in height, with a slightly raised margin, occupying part of the area away from the entrance (Fig. 6). Another feature occasionally noted is the presence of an external shelf or seat, about a foot in height, contrived in the re-entrant angle between two adjacent enclosures (Fig. 7).

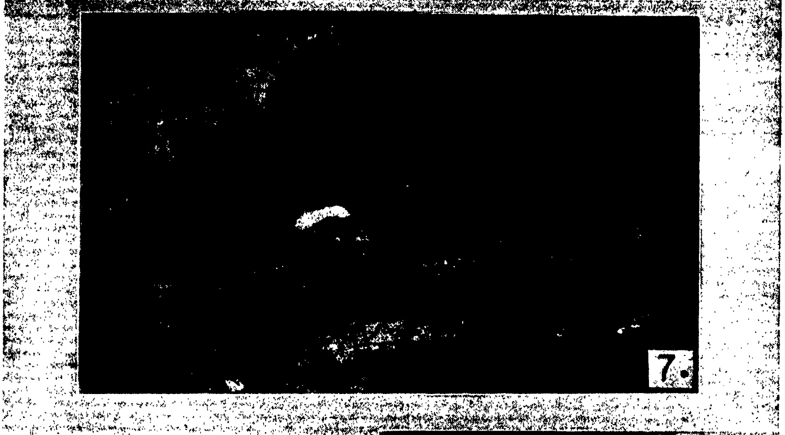
Remains of long low walls which cannot be interpreted as parts of enclosures have been encountered in certain parts of the cave, especially the darker portions. These probably served the double purpose of forming a pathway and a channel through which water coming through the cave entrance might be diverted from the enclosures on either side of it. There are abundant signs of water having poured into the cave, presumably during heavy rains. Several enclosures in a low-lying area have had the mud coating of their walls entirely washed away, leaving only the stone core, and the walls of a pathway or channel traversing this area are also partially demolished. The structures situated in more elevated parts of the cave have escaped this destruction and are generally well-preserved, though their walls are sometimes in part broken down. Near the entrance some of the remains are partially buried by débris from above.

RELICS FOUND IN THE CAVE. The first explorers of the cave discovered one or two iron battle-axes still retaining their much-decayed wooden shafts, and a rusted assegai-head. We have not had the opportunity of examining these specimens, but according to Mr. Brumage the assegai-head was similar to examples from Basutoland. Bones supposed to be human were also observed, but crumbled when touched.

Remains found on our visit comprise an abundance of coarse pottery, some fragments of ostrich-egg shell and a few bones and teeth of animals.

The pottery is hand-moulded from a clay containing numerous fragments of stones, some of considerable size. It is very unevenly fired, most sherds displaying a brown, grey or black core with the outer and inner surfaces more intensely fired and of a buff or occasionally a light red colour. Most of the sherds belong to thick-walled globular pots of large size, with a wide mouth surrounded by an incipient or short neck, usually somewhat flared. Pots of smaller size but of the same general form are also represented, as well as a deep shouldered bowl with a markedly everted lip. The rim finish varies considerably, being in some cases simply rounded, in





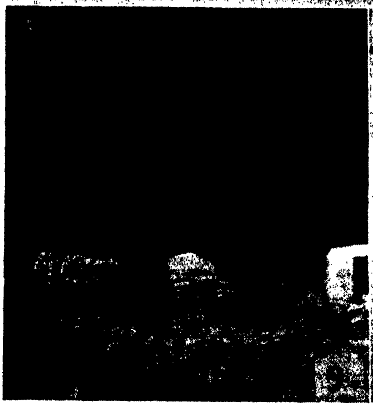


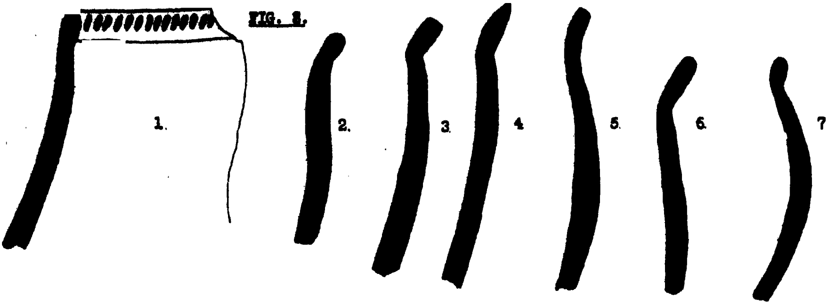
Plate II. (6) Clay bench with enclosure, Gatsrand site.
(7) Clay shelf on exterior of enclosure wall, Gatsrand site.
(9) Remains of modern Basuto village in large rock-shelter, Sikulu, Basutoland.
(10) Remains of hut in small rock-shelter, Caledonpoort, Fouriesburg, O.F.S.

others square-cut, while in several specimens there is a definite external overlap or roll. Only one specimen shows any decoration, the rolled lip bearing a series of oblique, slightly crescentic indentations on its outer surface (Fig. 8).

Ostrich eggshell was found as irregular fragments of varying size; no artefacts of this material were discovered.

Many of the skeletal remains encountered, including horns of sheep and cattle, appear to represent animals which had fallen through the cave entrance in recent times. In one of the deeper parts of the cave, however, there were found disintegrating fragments of bone including a number of teeth of the bontequagga (*E. burchellii*). One of these teeth had been burned.

FIG. 8.



(1) Globular pot, with a flared rim decorated with a single row of oblique slightly crescentic indentations. The rim is rounded, and the pot is blackened with much burning.

(2) Globular pot with a flared neck and a rounded rim. This specimen is blackened with much burning.

(3) Globular pot with a short flared neck and a square rim. The pot has a reddish-brown matt surface.

(4) Globular pot with a short flared neck and a tapered rim. The pot has a reddish-brown matt-surface.

(5) Small shouldered pot with a flared, square rim. This specimen has a buff matt surface.

(6) Globular pot with a short, markedly flared neck and a square rim. The pot is blackened with much burning.

(7) Deep bowl with an incipient neck and a rounded rim. The bowl has a buff matt surface.

THE ZEEKOEIFONTEIN (LINDEQUESDRIFT) SITE.

THE CAVE. This cave is in a valley trending north and south, its entrance being situated about halfway up the slope on the eastern side of the valley. While no detailed account of the geology can be given, it appears that the cave is developed in the upper part of the Dolomite series, or possibly in the contact zone between the Dolomite and the Pretoria series as in the case of the Gatsrand cave. No remains have been observed on the surface in the immediate vicinity of the cave. From the opening, which is about three feet in diameter, a vertical fissure descends some ten or twelve feet. At the lower end of this fissure a low arch over loose talus leads into the main chamber of the cave, which measures about one hundred feet by sixty. The floor of this chamber, except for a small portion at the end remote from the entrance, is formed by a steep talus slope; the roof in the middle rises to a height of forty to fifty feet above the floor. From the sides and end of this chamber open several recesses and narrow passages leading to small chambers.

CONSTRUCTIONS IN THE CAVE. The small enclosures, which were situated along the side walls of the main chamber, are much less numerous than in the Gatsrand cave, only some eight examples having been noted by the University party. As at Gatsrand, they are of an irregular form approximating to a circle, a well-preserved example measuring 7½ by 8 ft. internally. In most cases, one side is formed by the rock surface faced with clay, the remainder being enclosed by a wall of clay hand-moulded over a core of stones. These walls are somewhat lower than those of the Gatsrand structures, none apparently exceeding two feet in height, while the best preserved specimen has walls not more than one foot in height and four to six inches thick. This example is peculiar also in the structure of its entrance. Instead of the wall being simply interrupted, it is carried out on either side of the opening so as to form a short angulated passage, thirteen inches wide at the outer and sixteen at the inner end. Some of these structures have a definite clay floor continuous with the walls; others however are floored only by the earth and rubble of the cave floor. No internal constructions were observed in any of these enclosures.

RELICS FOUND IN THE CAVE. Embedded in some six inches of dusty soil which had accumulated on the floors of the enclosures were fragments of basketry and portions of mealie-cobs. In the vicinity of the enclosures also were numerous sherds of coarse pottery. This is of the same general character as that found in the Gatsrand cave, and like it is devoid of any really distinctive feature. Most of the determinable fragments belong to round-bodied pots with more or less sharply defined short necks. Decoration is present on only one specimen, which shows the remains of a triangular or zig-zag pattern executed in broad shallow incisions on the wet clay. Many pieces show by the dense coat of soot adhering to them that the vessels had been used on the fire.

Other remains of material culture found in the cave include pieces of dressed hide, presumably portions of garments. The only metal objects recovered by the University party were some fragments of iron strips about 6-8 mm. in breadth and 3-4 mm. in thickness, probably portions of armor anklets. A previous visitor to the cave found a penannular copper armlet 74 mm. in diameter, made from a rod of approximately circular section with a diameter of 7·5 mm. There were also found in direct association with human remains a number of well-made ostrich eggshell beads, 5·5 to 6·5 mm. in diameter, and a single small cylindrical glass bead, opaque red over transparent green, measuring 3·5 x 4 mm. in diameter and 3·5 mm. in length.

Human as well as animal remains have been found in abundance in this cave. The bulk of the animal bones are those of baboons, but remains of domestic animals, especially cattle, are also present. Human bones representing a considerable number of individuals, adult and juvenile, of both sexes, were recovered by the University party; many of these were dissociated, others, however, belonged to partial skeletons still in articulation and even covered by mummified remains of the soft tissues. Unfortunately, every human skull, and even those of the baboons, had been removed by previous visitors, only two imperfect human mandibles being found by the University party. (It is reported that Dr. T. N. Leslie many years ago collected several human skulls from this cave; these were sent to Vienna, but so far as is known no account of them was ever published.)

In the present imperfect state of our knowledge of the differential characters of the parts of the skeleton other than the skull in South African native types, it is not worth while to give any detailed account of the skeletal parts collected. The mandibles are however deserving of brief consideration, since the racial characters of this bone are fairly well established.

The two mandibles, both of which are fully adult, differ remarkably in size and conformation. One specimen is very large and rugged, and in general conformation resembles those of certain very prognathic South African Negro individuals, the ramus being obliquely placed, the elongated body deep in the molar region, but even considerably deeper at the symphysis, and the blunt mental protuberance overshadowed by marked alveolar prognathism. In comparison with Negro mandibles, however, this specimen displays a number of characters of difference. Thus the ramus is lower and broader than in the typical Negro, the articular condyle much more flattened, and the anterior margin of the ramus separated by a distinct groove from the hinder end of the alveolar ridge. The dental arcade is very elongated and narrow, with almost straight converging sides; on the internal aspect of the body over the roots of the second premolar and first molar there is a prominent *torus mandibularis*. Many of these characters suggest the intrusion of the robust pre-Negro type represented by the Boskop and Springbok Flats remains.

In contrast to the first specimen, the second is notably small and delicate in construction, the difference being far greater than can be accounted for by sex alone. This second mandible is comparable in dimensions with those of Bushmen, but differs appreciably in its conformation, the ramus being proportionately higher, while the body is not so thick in the molar region. These differences from the Bush type are consistent with a Negro infusion. Thus both mandibles, although so widely divergent, appear to indicate a blending of Negro and pre-Negro (Bush and " Boskopoid ") elements, the Negro predominating in the larger and the pre-Negro in the smaller specimen.

DISCUSSION.

No exact counterpart to the underground constructions observed on these two sites has to our knowledge been previously reported in this area. These remains therefore present a two-fold problem: the identity of their makers and the purpose for which they were designed.

Local native tradition suggests possible answers to both of these questions. In the case of the Gatsrand cave the natives now living in the immediate vicinity of the site disclaim any knowledge of it. We have however been informed by Mr. Brumage that there are Bechuana natives now living not far distant from the site who claim to be descended from the inhabitants of the cave. These people maintain that their ancestors took refuge in the cave from Moselikatse and his Matabele. A generally similar story was given in the case of the Lindequesdrift cave by Pedi natives living in the vicinity. By these informants it was reported that the cave was in pre-Voortrekker times a refuge of the BaFukeng (? or BaPhuti) tribe. The human remains were said to be those of members of this tribe trapped in the cave by " Zulus " who suffocated them by lighting fires in the entrance. These informants identified the subterranean structures as the foundations of granaries.

The remains found at Lindequesdrift are entirely consistent with the ascription to a Bantu tribe. This is particularly true of the pottery, which though crude and lacking any highly distinctive features has the general characters of Bantu wares. The inhabitants also possessed both iron and copper artefacts, as well as cultivated grains. So far as the human remains have been interpreted, they reveal the mixed Negro and pre-Negro character frequently observed in skeletons from sites of early Bantu occupation. The single imported bead from this site belongs to a type which there are good reasons for attributing to the late eighteenth or early nineteenth century (Schofield 1938). There is thus good warrant for supposing that the occupation of this site was catastrophically terminated during the epoch of the Matabele and Mantatee raids, circa 1820-1830.

In the case of the Gatsrand site there is less archaeological evidence to confirm the similar dating indicated by native tradition. The cultural material most intimately associated with the underground structures is the pottery, which has the same generally Bantu facies as that from Lindequesdrift. The iron implements found by the first explorers appear to be also Bantu in type; it is possible however that these could have been introduced by some other people than those responsible for the underground constructions. At most, therefore, it may be said that nothing in the evidence is inconsistent with the ascription of the remains to an origin and age similar to those indicated for the Lindequesdrift remains.

It cannot even be dogmatically asserted that the constructions above and below ground at the Gatsrand site are the work of the same people. That this was the case is suggested, however, by the apparent identity in the mode of construction of the enclosures in the cave and of the " hut " circles above ground, though continuous exposure to wind and rain has denuded the surface constructions of their clay coating. The surface settlement appears thus to have consisted of stone-and-daub huts and small walled enclosures, presumably kraals for domestic animals. The stone mounds are an enigma, but may perhaps be the remains of granaries.

If then it is reasonable to conclude that the surface and underground structures at the Gatsrand site were due to one and the same people, it remains to determine the function for which the underground structures on this site and the apparently comparable ones in the Lindequesdrift cave were intended. In the latter case, these structures have been identified by natives as intended for granaries. This interpretation is supported by the association with the structures of remains of corn and portions of basketry as well as pottery. Apart from these remains there is no evidence of the cave having been inhabited for any lengthy period of time. The other cultural relics all appear to be the personal adornments of the individuals whose skeletons were found in the cave; the disposition of these remains is quite consistent with the tradition of a massacre. Although no surface remains were observed in the vicinity, it seems probable that the Lindequesdrift cave was used only as a storehouse and occasional refuge.

It is natural to presume a similar explanation for the structures in the Gatsrand cave. There are, however, certain differences between this site and that at Lindequesdrift which must be considered. The underground constructions at Gatsrand are much more numerous and in several respects more elaborate; their walls are higher, and internal raised benches are sometimes found. These arrangements suggest the possibility that the Gatsrand structures may have been dwellings. Without exception, however, they are now roofless, and display no evidence that a roof was ever part of the structure. In some cases, indeed, there is too little space between the walls and the overhanging rock for anything but a flat cover.

In this connection it may be observed that the first explorers found the decayed remains of upright poles, sometimes outside and sometimes inside the huts. According to Mr. Brumage, these poles, or the holes in which they had stood, occurred only where there was water dripping from the rocks above. It is possible that these poles may have supported a roof or awning separate from the wall structure.

That some habitation took place in the cave is suggested by the fact that the roof in several places appears to have been blackened by smoke. Moreover, at the extremity of one of the secondary chambers there is a pool of apparently permanent water. Judging by the number of potsherds in its vicinity, this was extensively used as a water supply. However, apart from the potsherds, some fragments of ostrich egg shell and a few remains of animal bones, the cave is conspicuously free from refuse and no mealie-cobs have been found. Here again, it appears that occupation could not have been continuous over a long period.

Constructions, and even quite definite dwellings in caves and rockshelters are known in other parts of South Africa. In most of these cases the circumstances are appreciably different from those obtaining at Gatsrand and Lindequesdrift. In the Eastern Transvaal large stone-walled enclosures in caves are known, but no structures resembling huts have been observed. The construction of huts in rock-shelters has been recorded in the Basutoland area. An illustration of an inhabited village in a rock-shelter near Leribe is given by Christol (1930); remains of a similar village occupied up to a few years ago exist in a shelter close to the Sikubu mission station near Butha-buthe (Fig. 9). In both these cases the huts, whether built against the wall or standing free, are essentially of the ordinary Basuto type. The walls, of stone and clay, stand five to six feet in height, and were crowned by a pointed roof of thatch, the shelter roof rising high above the huts.

At Caledonpoort on the Basutoland border between Fouriesburg and Butha-buthe there are dwellings under small shelters and overhangs. These are enclosed by a wall of stone or sod faced with clay, which is carried up to meet the overhanging rock (Fig. 10), the height being merely four to six feet. The rock thus forms the roof as well as the back wall of the hut. These constructions are known to have been in existence when the locality was occupied by Europeans after the Basuto War of 1864. That they are of no great antiquity is shown by the fact that in one case they are built against a face of rock bearing Bushman paintings in what appears to be a late style.

These remains afford an instructive contrast with those in the Gatsrand and Lindequesdrift caves. It does not appear that the structures in the Southern Transvaal caves can have been roofed in the manner of those of the Basutoland shelters. On the other hand, at Gatsrand, even where the cave roof is low the structure walls deliberately fall short of it, whereas at Caledonpoort they are carefully carried up to meet it. The conclusion appears warranted that the

Gatsrand structures were designed to be open above, although it has been suggested that in some cases they may have been protected by a separate awning.

Thus the evidence, so far as it goes, points to the conclusion that the people responsible for these constructions in the Southern Transvaal caves used these sites not as permanent habitations but as occasional shelters, storehouses and places of concealment. It is highly probable that other similar sites are to be found in the dolomite area of the Transvaal, and we may hope that enquiry will lead to the discovery of further examples from which more conclusive evidence may be obtained. These remains are clearly capable of throwing considerable light on one of the most obscure periods in South African archaeology, that which immediately precedes the historic period.

We wish to record our gratitude to those helpers whose names are mentioned in the text of this paper, and also to a great number of others who have furthered our investigations at different times.

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REMAINS FROM STONE-HUT SETTLEMENTS IN THE FRANKFORT DISTRICT, O.F.S.

BY

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The general character of the stone-hut settlements of the north-eastern Orange Free State has been described by van Riet Lowe (1927), Laidler (1935) and Daubenton (1938). This paper deals with material recovered from two typical groups of such settlements on the farms Rietspruit No. 81, and Kalkoen No. 151 in the vicinity of Frankfort, Orange Free State.

These two groups of settlements lie in a line extending approximately West to East. Another smaller group lies in between, but further South, more in the vicinity of Tweeling, on the farm Tweelingkop No. 221, belonging to Mr. W. Smalberger.

The farm Rietspruit No. 81, belonging to Mr. A. Krogman, lies about 15 miles south-east of Frankfort. This Rietspruit settlement is composed of a large number of "statte" lying on a ridge which extends from a northerly direction to East for about two miles, then passes south-east for a short distance, and curves towards the south. The landscape is undulating in character with small hills and wide sweeping valleys. This settlement occupies the prominent parts of the ridge, the valleys bearing no visible indications of similar settlements.

The Kalkoen settlement, a comparatively large one, consisting of four large "statte," is located on the farm Kalkoen No. 151 about four miles west of Frankfort, belonging to Mr. H. J. van Rensburg. This settlement is built on a ridge similar to the Rietspruit settlement, and lies roughly in a west-south-westerly direction. These "statte" have been almost entirely destroyed.

Relics of Material Culture. These have been obtained almost entirely from excavation in the ash middens which occur in relation to these settlements. They comprise an abundance of pottery fragments and a number of other miscellaneous objects.

Pottery. The pottery appears to have been hand-made, there being no indications of the use of a wheel. All the sherds show evidence of firing, probably over an open fire. The clay used can be conveniently described in two groups, which differ very conspicuously in texture. The one type is of a fine texture having minute granules of grit, and giving the pottery a fairly homogeneous appearance. The other type is markedly granular having pieces of grit measuring up to 5 mms. The thicknesses of the sherds vary from 4 mms. to 2 cms., the majority, however, averaging 0.9 cms.

Although the material is very fragmentary most of the vessels can be identified as falling in one of the following classes:—

Pots — with well-defined necks (Nos. 1 and 2).
with ill-defined necks (Nos. 8 and 11).
without necks (Nos. 14 and 15).
Bowls — narrowed at neck (Nos. 18 and 19).
widest at neck (No. 21).
Cups — (Nos. 22 and 24).
Miscellaneous pieces—
Flat bases (Nos. 45 and 46).
Pipes (No. 44).
Spoons (No. 47).

Three ways of treating the lip are recognisable: rounding-off (Nos. 14 and 22), flattening (Nos. 8, 11 and 15) and rolling back (Nos. 4, 6 and 8).

The surfaces of the fragments have been finished in three ways. A few are definitely burnished (Nos. 29 and 36), a number of others have a matt finish (Nos. 4, 6 and 7), while the remainder are merely smoothed by the hand (Nos. 11, 21 and 23). Of these that are hand-smoothed, some are finely smoothed such as Nos. 15 and 24, while others are left extremely rough (Nos. 11 and 21). Some of the fragments have been untouched by the application of any pigments (Nos. 4 and 11), others have been coloured either red (Nos. 2 and 29), or black (No. 36). Most of the fragments to which colour has been added show distinct signs of burnish (Nos. 2, 29 and 36).

While a number of vessels show no trace of any decoration, many display more or less elaborate decorative treatment of the lip, neck and shoulder. Four distinct methods of decoration can be recognised:

(a) Moulding—as by the tips of the fingers, or by carving fairly wide and shallow notches (Nos. 7, 11, 21, etc.).
(b) Lines incised on the wet clay (Nos. 6, 37, 42, etc.).
(c) Impressed comb or stamp marks (Nos. 4, 29, 36, etc.).
(d) Applique moulding (Nos. 5 and 23).

These various methods have the common character of being executed in the wet clay.

Miscellaneous Objects. Under this head have been grouped two iron objects and a number of bone fragments.

One of the iron objects is a leaf-shaped assegaai head of which the blade measures 10 cms. by 2.2 cms. The shank is 5.9 cms. long and of square section measuring 4 mm. at the base and tapering to a point. The other iron implement measures 11.1 cms. in length. It has a long shank occupying a little more than half the length and broadens out into a narrow blunt "blade." This blade is perforated by two holes, one 4 mms. in diameter, the other 3 mms. in diameter.

The bone fragments include, besides a number of portions of long bones, part of a mandible with very heavily-worn teeth, of a zebra, and some large teeth which appear to belong to the domestic ox. There is also among the bone fragments, a right human os hamatum.

HUMAN REMAINS

At Rietspruit No. 81 there occur, a little distance from the stone structures, a few large stones encircled by a number of smaller stones. Two of these circles were excavated and proved to be graves, removal of the centre stone and about eight inches of the underlying soil revealing the skeleton, which was in a sitting posture. Of the two skeletons exhumed, one is adult, the other juvenile.

The adult skeleton is fairly complete, yet curiously enough the skull was missing; one may suspect that the grave had previously been opened and the skull removed. However the mandible is present. It is of considerable dimensions, and the ascending ramus, which is relatively high, makes a wide angle with the body. The mandibular notch is shallow. In the volar region the body is slender, deepening rapidly towards the symphysis. The median mental protuberance is prominent, though the mental tubercles are not very marked. This projection of the chin is however overshadowed by the marked prognathism of the alveolar region. The dominant features of this bone are thus those of the South African Negro type.

From the remains of the pelvic bones it is clear that the skeleton is that of a female. The lengths of those long bones which are intact are: humerus (right) 30.1 cms.; radius (right) 24.1 cms., (left) 24.1 cms.. Ulna (right) 25.6 cms., (left) 25.4 cms.; femur (right) 43.5 cms.; tibia (right) 37.3 cms., (left) 37.3 cms.; fibula (right) 35.2 cms. These measurements afford estimates of the stature varying between 156.5 cms. (5 ft. 1½ ins.) and 166.5 cms. (5 ft. 5½ ins.); the mean value is 162.7 cms. (5 ft. 4 ins.), which is above the average for South African Negro females. It appears also from these measurements that the upper limb is short in comparison with the lower, and that the forearm and leg were very long in proportion to the upper arm and thigh.

The femur displays a degree of antero-posterior flattening of the upper part of the shaft much greater than is usual in the South African Negro, the platycnemic index being 74.2. There is a similarly marked degree of medio-lateral flattening of the shaft of the tibia, giving a platycnemic index of 60.6. Both these features point to the intrusion of a pre-Negro (Bush or Boskopoid) element into this skeleton. On the other hand the degree of pilastering of the shaft of the femur is not great, the index of 106.9 being more consistent with a Negro than with a pre-Negro character.

From these observations it may be concluded that this individual was preponderantly of Negro type, but with an admixture of Bush or Boskopoid characters.

The juvenile skeleton is that of a child aged about seven years; its sex cannot be determined. Unfortunately the skull is considerably distorted by the pressure of the overlying earth and stones, so that neither measurements nor a description of its general conformation can be given. Most of the details of its several parts, however, indicate that it belongs to a large headed pre-Negro (Bush-Boskopoid) type. Some of the indications of the intrusion of a Negro element are however present, particularly in the mandible, whose ascending ramus is relatively narrow and forms a very wide angle with the body of the bone. The teeth, which are very large, show a number of distinctive characters and are being studied by Dr. R. Broom. It may be remarked that the limb bones show no evidence of platymeria, pilastering or platycnemia; no inferences can however be drawn from this, since it is well established that these features undergo considerable variation during growth. the adult condition not being attained until the age of puberty. From the characters of the skull, however, this individual appears to be the converse of the adult specimen, displaying a preponderance of pre-Negro features with a minor Negro element.

CONCLUSIONS

The remains obtained from these settlements, like the sites themselves, agree very closely in their general character with those described in the publications already cited. They indicate that the inhabitants of the sites possessed pottery of a characteristic type, iron implements and domestic cattle. From the skeletons discovered, these people appear to have been of a mixed physical character, showing a blending in various proportions of Negro and pre-Negro types.

No attempt is made here to elucidate the problems which this culture still presents. The evidence from the Frankfort sites has, however, been set out so that it may be available for future discussions of this subject

I have to express my deep appreciation to Professor Raymond A. Dart for the kind interest and encouragement which provided the initial stimulus to this investigation, and to Professor van Riet Lowe for his kind permission and indeed encouragement to investigate these settlements. I am also indebted to Dr. L. H. Wells for his criticisms of the manuscript and diagrams.

I would like to offer my sincere thanks also to Messrs. Krogman, Bosman and van Rensburg for their kind assistance and keen interest, especially to Mr. and Mrs. Krogman for their kindness and gracious hospitality.

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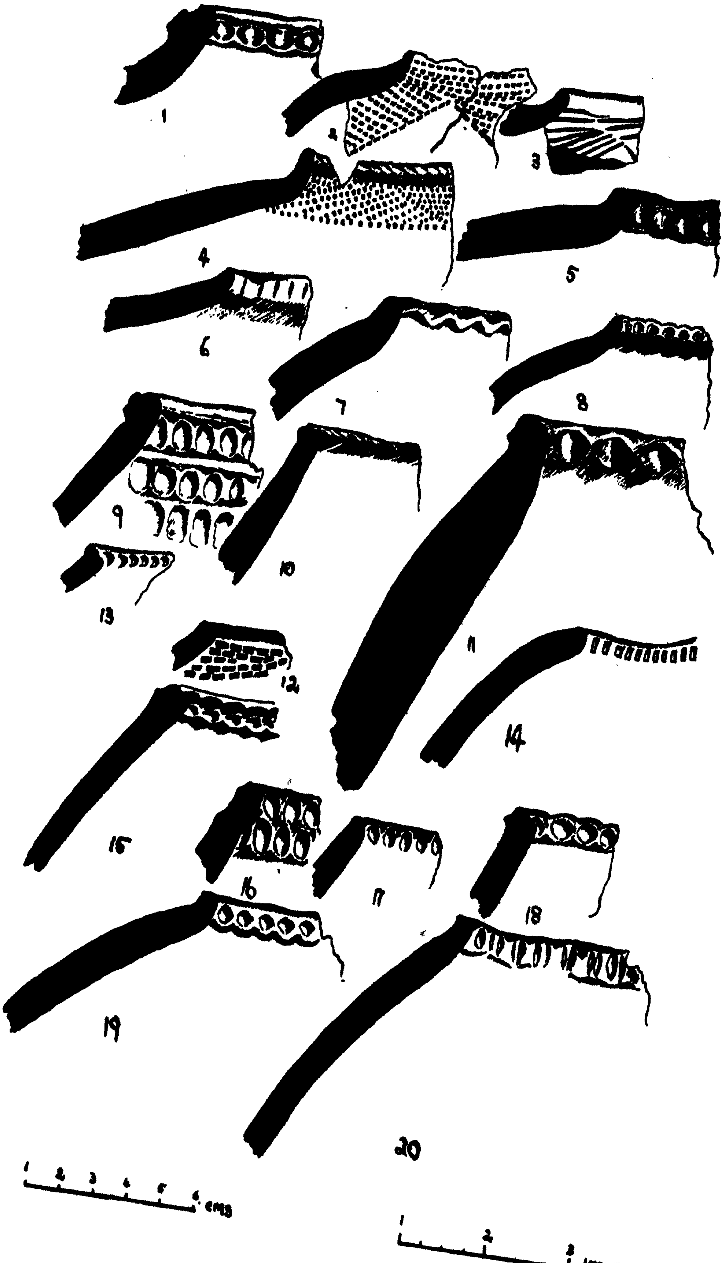
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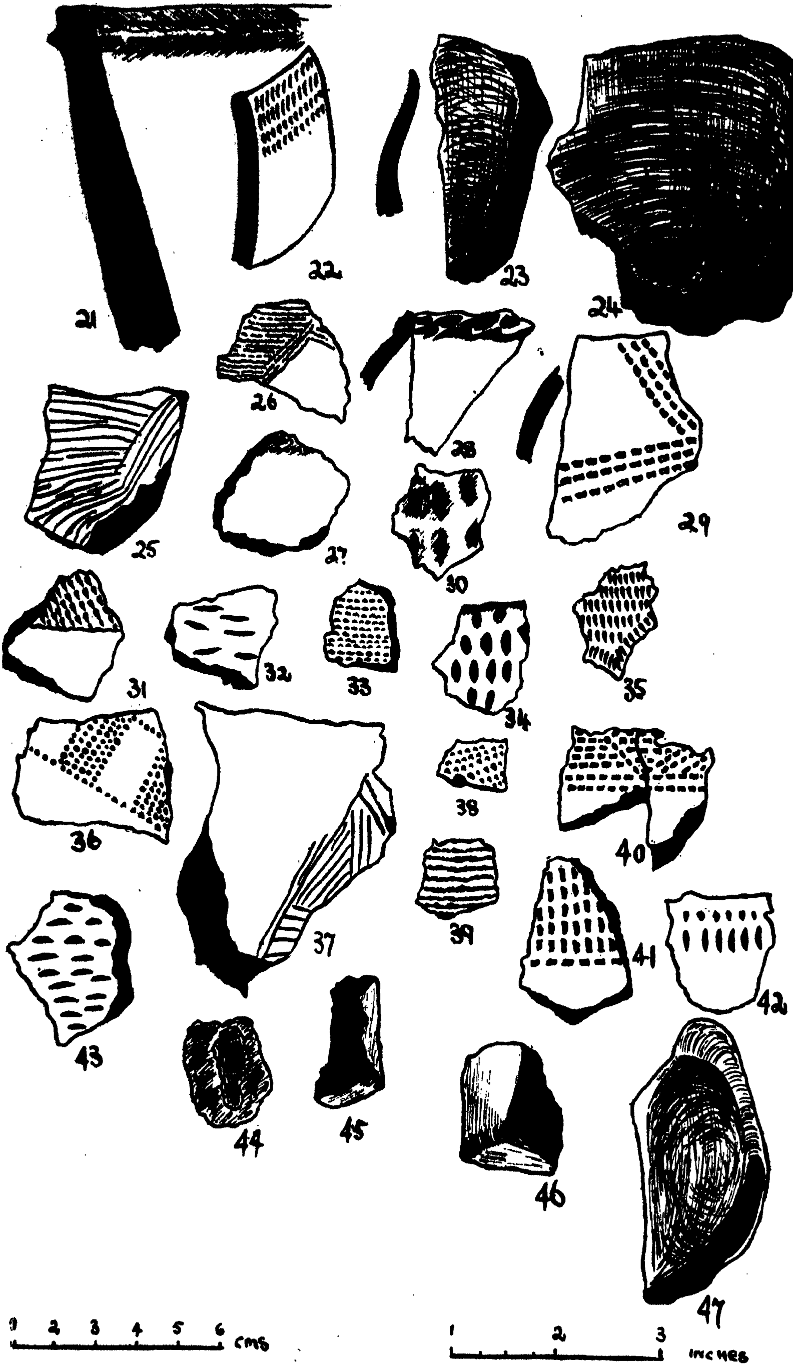
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DESCRIPTION OF FIGURES

1. Fragment of short necked pot, the diameter of the rim considerably smaller than greatest diameter; thickness 1 cm.; external surface blackish grey with a rough matt finish, internal surface blackish brown with a matt finish; the external surface has a strip of applique moulding where the neck joins the shoulder; from Kalkoen.
2. Fragment of lipped pot, in which the neck is narrower than the widest diameter, thickness .9 cm.; internal surface of the lip smooth, and burnished for a distance of about 1 cm.; but for a burnished triangular area, the external surface has a matt finish; external surface decorated by comb impressions; from Rietspruit.
3. Fragment of short-necked pot, .8 cms. thick; external surface has a matt finish, internal surface has a fairly smooth red burnish in upper part of neck, the lower part having a matt finish; shoulder decorated with horizontal and oblique incised lines; from Kalkoen.
4. Fragment of short-necked pot, .9 cm. thick; inner surface of neck has a fair burnish, external and internal surfaces red with a matt finish; external surface of shoulder decorated by comb impressions, the rim having a double row triangular shaped incisions; from Rietspruit.
5. Fragment of large short-necked pot, the diameter of the neck considerably smaller than the greatest diameter; thickness 1.1 cms.; external and internal surfaces blackish-grey with matt finish; external surface has applique moulding where the neck joins the shoulder; from Kalkoen.
6. Fragment of short-necked pot, .8 cm. thick; external and internal surfaces have a matt finish; outer part of tip of neck decorated by a single row of elongate incisions; from Rietspruit.
7. Fragment of large short-necked pot, thickness 1 cm.; external and internal surfaces dark greyish-red with a matt finish; external surface of neck is decorated by moulding; from Rietspruit.
8. Fragment of short-necked pot, .6 cms. in thickness; external and internal surfaces greyish-yellow with a matt finish; neck decorated by chipped incisions.
9. Fragment of rim of neckless pot, .8 cm. in thickness; external and internal surfaces greyish-black with uneven matt finish; neck decorated by moulding in four horizontal rows; from Kalkoen.
10. Fragment of neckless pot, 1 cm. in thickness; external surface brown, internal surface darker brown, both have a rough matt finish; lip rolled towards the exterior; from Kalkoen.
11. Fragment of neckless pot, greatest thickness at belly of pot 2.1 cms.; clay highly gritty having extremely large granules (3 mms.); external and internal surfaces brick-red, rough surfaces; rim compressed at top and decorated by double chip moulding; from Rietspruit.
12. Fragment of neckless pot, .7 cm. in thickness, composed of dark greyish-orange clay; external surface has matt finish, internal surface faintly burnished; decorated by horizontal rows of large comb impressions; from Kalkoen.

13. Fragment of small pot with rim rolled back, thickness 1.1 cms.; external and internal surfaces red and highly burnished; outer surface of rim decorated by semilunar impressions; from Rietspruit.

14. Fragment of neckless pot composed of darkly greyish clay, thickness .7 cm.; external surface blackened at the top and has a rough matt finish, internal surface has a smoother matt finish; lip decorated by a single row of large comb impressions; from Rietspruit.

15. Fragment of neckless pot, thickness .7 cm.; external surface brick-red, internal surface reddish-yellow passing into greyish-yellow, both have a matt finish; decorated by two horizontal rows of moulding; from Rietspruit.

16. Fragment of bowl in which the diameter of rim is considerably smaller than the greatest diameter; thickness 1.7 cms.; external surface dark brick-red, internal surface blackish brown, both have a matt finish; outer surface of rim has two horizontal rows of moulding; from Kalkoen.

17. Fragment of neckless pot, 1 cm. in thickness at shoulder; external surface orange-red, internal surface yellowish-orange, both have a matt finish; outer part of lip decorated by a single row of chipped impressions; from Rietspruit.

18. Fragment of neckless bowl, thickness .8 cm.; external surface bright orange, internal surface a greyish-black, both have a matt finish; outer part of lip compressed, decorated by a single row of chipped impressions; from Rietspruit.

19. Fragment of large neckless bowl, 1 cm. in thickness; external surface brick-red with the lower part blackened, internal surface earthy yellow, both have rough surfaces; rim compressed and decorated by moulding with double incised chips, from Rietspruit.

20. Fragment of fairly large pot, thickness .9 cm.; external surface darker red than internal surface, both have a matt finish; outer part of lip moulded and decorated by a single row of impressions; from Rietspruit.

21. Fragment of shallow bowl, diameter 5 cm., thickness 1.6 cms.; external surface dark reddish brown passing into dark black, the internal surface earthy yellow, both have a rough matt finish; outer part of lip decorated by oblique moulding; from Kalkoen.

22. Fragment of small cup, thickness .7 cm.; the external and internal surfaces reddish yellow with matt finish; upper part of shoulder decorated by four horizontal lines executed with fine comb impressions; from Rietspruit.

23. Fragment of small bowl, depth 4.4 cms., diameter 9 cms.; external and internal surfaces almost black and have a rough finish; outer surface of rim decorated by a single row of impressions; from Kalkoen.

24. Fragment of small cup, rim diameter 9 cms., depth 5.5 cms., base 1.4 cms. thick; external and internal surfaces brownish black and have a rough finish; from Rietspruit.

25. Fragment containing large granules of grit, thickness 1.2 cms.; external and internal surfaces red and have a matt finish;

external surface decorated by horizontal and oblique lines; from Rietspruit.

26. Fragment of large pot, thickness 1 cm.; external and internal surfaces brownish-black, external surface having a matt finish with a faint burnish, internal surface rough matt finish; external surface is decorated by a number of horizontal lines of comb impressions—these lines forming a rough V; from Kalkoen.

27. Fragment of bowl, thickness .6 cms.; external surface has a faint red burnish, internal surface matt finish; upper end of shoulder decorated by two horizontal rows of comb impressions; from Rietspruit.

28. Fragment of neckless pot, thickness .7 cm.; diameter of rim considerably smaller than greatest diameter; external surface brick-red, internal surface blackish-brown, both have a matt finish; outer surface of rim moulded; from Rietspruit.

29. Fragment of bowl, .9 cm. in thickness; external surface has a red burnish, internal surface matt finish; external surface decorated by impressions forming two limbs of a triangle, each limb composed of three parallel rows of large comb impressions; from Rietspruit.

30. Fragment of pot, thickness 1.7 cms.; external surface blackish-grey, internal surface brownish-grey, both have a matt finish; external surface decorated by faintly visible parallel rows of impressions; from Kalkoen.

31. Fragment of bowl, .6 cm. in thickness; external surface half red and half black and has a rough finish, internal surface matt finish; external surface decorated by horizontal rows of comb impressions which intersect one another; from Kalkoen.

32. Fragment of pot, thickness 1.1 cms.; external surface blackish-grey with a matt finish, internal surface reddish-orange with a rough finish; the external surface decorated by elongate comb-teeth impressions; from Rietspruit.

33. Fragment of pot, .9 cm. in thickness; external surface orange-red with a matt finish, internal surface darker red with a faint burnish; external surface decorated by horizontal rows of comb impressions; from Rietspruit.

34. Fragment of neckless pot, thickness .8 cm.; external and internal surfaces brick-red and have a matt finish; external surface decorated by a number of semilunar incised impressions; from Rietspruit.

35. Fragment of bowl, thickness .7 cm. composed of dull greyish-red clay; external surface has matt finish with faint traces of burnish, internal surface matt finish; the external surface is decorated by rows of elongate comb impressions—five horizontal rows intersecting an oblique row; from Rietspruit.

36. Fragment of pot, thickness .8 cm. composed of a reddish-orange clay; external surface blackened and shows a faint burnish, internal surface has a matt finish; the external surface is decorated by two wide horizontal parallel rows of comb impressions between which are poised two rectangular blocks composed of a number of oblique rows of comb impressions; from Rietspruit.

37. Fragment of shoulder of pot, thickness 1.1 cms.; external surface has one half orange and the other bluish-black, and like the internal surface has a matt finish; external surface decorated by irregulr oblique incised lines which intersect at the lower part a single incised line and joined on the one side by three shorter incised lines; from Rietspruit.

38. Fragment of reddish-orange clay, thickness 1.6 cms.; external surface matt finish, internal surface red burnish; external surface is decorated by incisions on lip intersecting five oblique rows of comb impressions; from Kalkoen.

39. Fragment of thickness .7 cm.; dull reddish-yellow; external surface has matt finish with a faint burnish, internal surface matt finish; external surface decorated by seven parallel rows of comb impressions stamped into horizontal lines; from Rietspruit.

40. Two fragments, .8 cm. thickness; reddish orange in colour. external and internal surfaces matt finish; upper edge of internal surface red with a faint burnish; external surface decorated by comb impressions; from Rietspruit.

41. Fragment of pot, 1 cm. in thickness; external surface has a faint burnish, internal surface matt finish; external surface decorated by faint comb impressions arranged vertically on a horizontal base; from Rietspruit.

42. Fragment of pot, .7 cm. in thickness; external and internal surfaces matt finish; external surface decorated by two parallel lines of incised impressions; from Rietspruit.

43. Fragment of pot; external surface orange-brown; internal surface bluish-grey, both have a matt finish; external surface is decorated by a number of parallel semilunar impressions; from Rietspruit.

44. Irregularly shaped fragment with a rounded groove running along the inner surface; length 3 cms., thickness .9 cms.; external surface convex, roughly cylindrical, greyish-yellow and irregularly smooth; this is apparently a fragment of a pipe; from Kalkoen.

45. Large fragment apparently of a flat-bottomed pot; external surface irregularly smooth; orange-yellow passing into blackish-grey; the internal surface chipped and is a dark greyish-black; from Rietspruit.

46. Wedge-shaped fragment similar to No. 45, differing only in colour and the angle at the base; external surface dark brick-red with black base, the interior surface is smooth and forms the interior of the pot; from Rietspruit.

47. Large fragment forming the lowest half of the belly of a spoon, 6.6 cms. in length and .7 cms. in thickness; external and internal surfaces yellowish-orange with smooth matt finish: unbroken edges evenly rounded and smoothed off.

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A SECRET MUSICAL INSTRUMENT; THE EKOLA OF THE OVAKUANYAMA OF OVAMBOLAND

BY

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Read 30th June, 1941.

In May, 1935, a number of Ovambo natives were brought to Windhoek in connection with the South-West Africa Home Industries and Agricultural Exhibition. These natives brought with them all the articles used by them in their daily life, and they even erected a typical village in the outskirts of the town.

The Council of the University of the Witwatersrand gave me the opportunity, in company with Mrs. A. W. Hoernlé and Dr. Alexander Galloway, of visiting Windhoek and studying the habits of these natives, and during the few days that I was there I heard a number of musical performances, made notes about them, and even recorded several characteristic songs by means of a dictaphone.

In addition to these activities, I examined the objects in the local Museum, and found there what was obviously a musical instrument of a most unusual nature, and of a type that I had neither seen nor read of before. As I was informed that the instrument had been acquired from the Ovambo, although no details of its acquisition or description of its use had been secured, and since I had not observed a specimen among the natives whose music I had been studying, I asked for and received permission to take the Museum example to the Ovambo village in order to discover whether or not it was known to the tribesmen. It was, and the production of the instrument caused a good deal of merriment which was not unmixed with amazement.

I managed, with the generous help of Captain Hahn, who interpreted for me, to obtain a certain amount of information regarding the instrument, but it was obvious that the natives were holding back a good deal, and the reason for this appeared to be the presence of European women.

They did, however, send for a young man who, they said, was a performer upon the instrument, and when he appeared, and after the women had withdrawn, he gave me a demonstration of the use of it. I was also able to photograph the player and to record his song.

Hitherto I have not published a description of the instrument, but I have decided to do so now, since I have discovered that it was seen on the Angola border towards the end of the seventeenth century, though it was not then described.

I owe this new information to the fact that Dr. Robert Broom kindly sent over to me from Pretoria the German edition of the travels of P. Joanne Antonio Cavazzi in the Congo, Angola and Matamba, published at Munich in 1694. This work contains a short section on the music, musical instruments and dances of the natives of those parts (^{1}). Altogether ten musical instruments are described by Cavazzi in his text, the native names of five of them being given. The descriptions are sufficiently detailed to make identification of the instruments certain, and, in addition, five of them are shown in the hands of performers on various plates.

But two plates (^{2}) give illustrations of performers upon three musical instruments (or perhaps even four, as one is not absolutely clear), which are not described in the text, and one of these contains a drawing of a seated native playing upon what I am convinced is the instrument which I found in Windhoek Museum (^{3}). The engraving is, of course, crude, having doubtless been executed in Europe from either a rough sketch made in Africa or from a mere verbal description. The drawing contains six figures, these being a dancer, four instrumentalists, and one spectator. The picture would suggest that the four players form a musical ensemble which is providing music for the dancer, but this is not the case, for mixed ensembles of this nature are not normally found in Africa. The fact is that the picture is a composite one, of a type that has even survived to the present day, and which invariably leads to misconceptions.

The instrument with which we are immediately concerned is seen in the hands of the seated player on the lower left-hand corner of the engraving, which is reproduced on Plate 1 (^{4}). It consists of a very large calabash, open at the narrow end, along which has been secured a strip of wood or other similar pliable material, the front face of which has been regularly notched along its entire length.

The method of attachment is not shown on the drawing. In his right hand the performer holds a short stick, with which he is apparently stroking the notched strip. In the same picture another instrument, in which the sound is produced by drawing a stick along a notched surface, is also shown, but this type is well-known and has been frequently described, although Cavazzi does not do so in his text. Further it has not, so far as I know, the strange significance of the other.

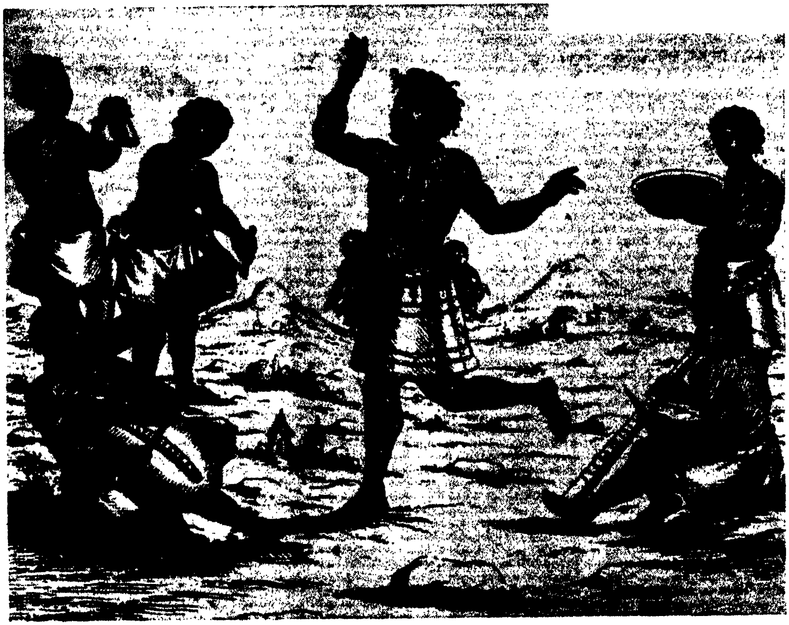


Plate I. Cavazzi's Ekola Player.

As I found it in the Windhoek Museum, the instrument consisted of a resonator formed from four calabashes, of different sizes, joined together so as to make a single resonance chamber, holes being made at the points of junction. The two end calabashes had small circular openings at their extremities, and the largest calabash had also a circular opening on its upper side. Over the entire resonator was bent a thin strip of palm rib, notched along its entire upper surface, and kept in position by a cord of fibre which ran through the resonance chamber from end to end. The stick with which to stroke the notches was missing.

When I first showed this instrument to the Ovambo, they were, as I have said, surprised and amazed, but sent for a performer. This man first obtained five thin twigs between eight and nine inches long and one rather thicker one, but less than half that length. He then squatted upon the ground, and, scraping away some of the earth in front of him, placed the instrument securely in the hollow thus formed. Then, taking the bundle of thin twigs in his right hand and the single one in his left hand, which grasped it in a most unusual manner, he bent over the instrument and began to sing, emphasising the accents by vigorously stroking the notched bow with the twigs in varied rhythms. The right hand always preceded the left hand, and the action was downwards, or away from the body. The bundle of twigs was held in the right hand in a perfectly natural manner, but the stick held in the left hand was passed over the fore and little fingers, but under the middle finger, the hand forming a cup-like hollow.

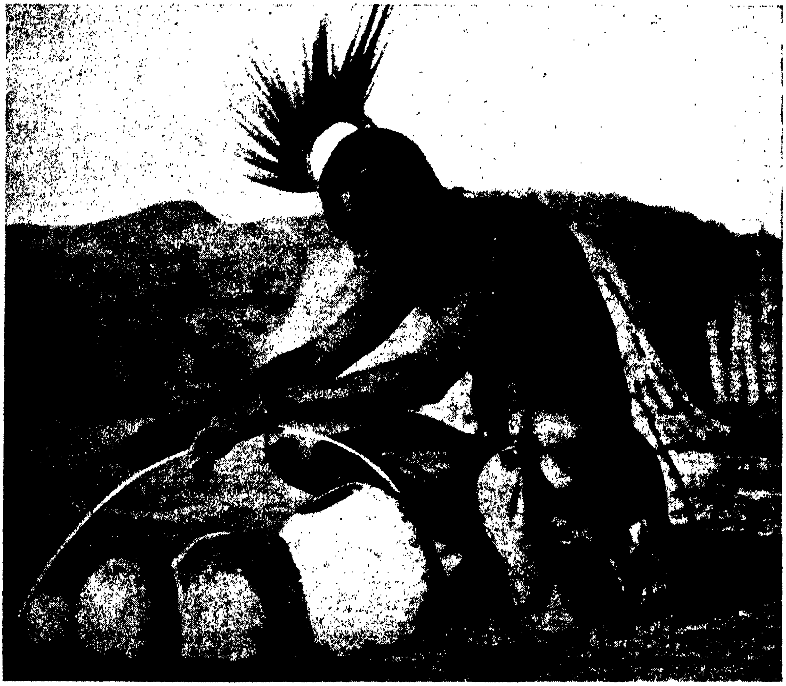


Plate II. "The Ekola Player."

The natives' description of the *ekola*, as they called it, and of its manufacture, was of considerable interest. The specimen which I had brought to them was, they said, a small one. The best type, as made and played by the

Ovakuanyama of Ovamboland, consisted of only one very large double calabash (this suggestion of course supports the illustration given in Cavazzi); but if two or more calabashes were used they were sewn together with stitches of fibre, and the outside of the joins plastered with dung over a plaiting of fibre.

But the description of the function of the instrument was manifestly obscure and incomplete, and the natives seemed unwilling to elaborate their explanations at this juncture. As far as we could at first discover, the *ekola* was used only for accompanying the songs of a doctor of some kind. Then the suggestion was made that only women and girls could join in the song. This statement was almost immediately contradicted, and it was then said that both men and women might play upon it. This, too, was vetoed, and I was told that what was really meant was a " half man, half woman." Captain Hahn and I came eventually to the conclusion that the natives were attempting to describe a hermaphrodite. This was subsequently found to be wrong.

Mr. A. C. Logie, of Windhoek, who was also present, volunteered to follow up the investigation on my behalf, and to endeavour to arrive at the truth. He discovered after prolonged cross-questioning, that the natives' reference to " half man, half woman " did not mean " hermaphrodite," as we had supposed, but " sodomite." His final description of the use of the instrument is as follows:

" Although not itself a particularly attractive instrument, the *ekola* plays a most interesting part in the life of the Ovakuanyama. It is essentially connected with sodomy, and is played in the first instance by the medicine man, who encourages this practice. To him it is a source of revenue, as he obtains a ' fee ' from every man he has enticed to be a partaker. In the second place it is played by the sodomite himself. When an Ukuanyama man falls a prey to this practice he discards his weapons, his bow, his arrows and his assegai (the distinguishing marks of manhood) and plays the *ekola*. He is no longer regarded as a man, but as one whom God has intended to be a man, but who is after all only ' half man, half woman.' He who once plays the *ekola*, therefore, is branded in the eyes of his tribesmen.

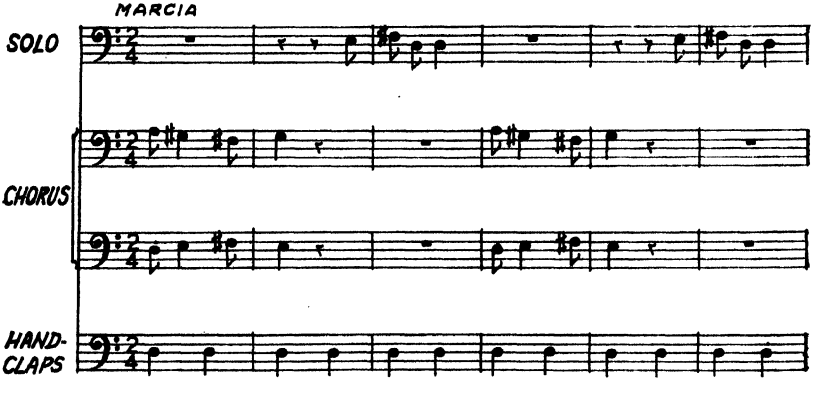
There is consequently something secret, almost mysterious, about the instrument, arising perhaps out of fear of too much publicity, and possible expulsion by the chief. Hence, too, the singing in subdued voices, the muffled nature of the music, and the vague, though suggestive, words of the singers:

'We are walking,
Carrying a crying baby.
We *may* be going to a party.'

This is the song of the sodomite, sung to the accompaniment of the *ekola*."

The music which I heard sung to the accompaniment of the *ekola* was antiphonal in character, the soloist, who was the *ekola* player, alternating with the chorus, which sang in two parts, and also clapped hands in the same time as the *ekola*. It is only possible here to give a few bars of the song; the part sung by the soloist was varied from time to time, but that of the chorus remained the same throughout.

EKOLA SONG



The secrecy which enshrouds the *ekola* explains why it has eluded most travellers, and why Cavazzi did not describe it, although he gave an illustration of it, and also emphasised the "indecent" nature of many native dances and rites which he saw or of which he heard.

It would appear that in the *ekola* we have an example of a ritual musical instrument of considerable antiquity, the true nature of which has hitherto remained unexplained, and the use of which has, in spite of the march of civilisation, lingered on to the present time.

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2. *Ibid.*, Plates facing pp. 185 and 196; French edition, Plates facing pp. 46 and 50.

3. *Ibid.*, Plate facing p. 196; French edition, Plate facing p. 46.

4. This photograph is a reproduction of the Plate in the French edition. There is no serious difference between the French and German Plates, except that the one is the reverse of the other. as is commonly found when a Plate is copied from one book into another.

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THE HEERENLOGEMENT AND ITS VISITORS; THE STORY OF ONE OF SOUTH AFRICA'S "HISTORICAL MONUMENTS."

BY

Percival R. Kirby.

Read 30th June, 1941.

When it first occurred to me to visit the famous cave in the Clanwilliam district of the Western Province now known as the Heerenlogement, I was aware that it had been visited, in September, 1927, by Dr. Ernest E. Mossop and described by him (1), but unaware that it had been visited still earlier, in September, 1911, by Professor H. H. W. Pearson, and also described by him (2).

Both these gentlemen had special reasons for visiting the place. Dr. Mossop was searching for the old northern roads which were opened up by the early Dutch pioneers, and Professor Pearson was on a Percy Sladen Memorial Expedition. Both, however, like not a few of their predecessors who found their way there, succumbed to the magic of the Heerenlogement and its history, and so both their accounts include a certain amount of historical information about the cave and its visitors.

My own reason for travelling thither arose from the investigations which I have been making into the life and work of Dr. Andrew Smith, the army surgeon who is known to all students of natural history by his great *Illustrations of the Zoology of South Africa.* In the course of my research I discovered that Smith had visited the Heerenlogement in 1828, and had noted down, though inaccurately, the names of a few of the distinguished men which he found inscribed on its northern wall (3). I was anxious to see for myself whether Smith or any of his companions had added their names on that occasion, and also to discover precisely how many had been written upon the rock, since no traveller ever appeared to have made a complete list, though a number of names were recorded by not a few, several of which were common to more than one list. I determined to obtain every legible name.

It happened, fortunately for me, that towards the end of 1940 my son, who had joined the Meteorological Section of the South African Air Force, was stationed temporarily at Klaver, not far from the Heerenlogementberg. I accordingly seized the opportunity to inspect the cave, and planned my visit well ahead, a very necessary precaution to take when one realises the nature of the country.

Before leaving for Klaver, I re-read all the early descriptions of the district and of the cave itself with which I was familiar through my previous study of Africana. In addition, I consulted Professor C. van Riet Lowe, who, in his capacity of Secretary to the Historical Monuments Commission, gave me copies of the correspondence which he had had with Mr. Dekanah, the Magistrate of Van Rhynsdorp, when arranging for the proclamation of the cave as an Historical Monument, and the placing of the Commission's plaque on the rock face.

In one of the letters written by the magistrate, dated 10th April, 1940, I read that " The roads are execrable and we wasted hours getting stuck in the thick sand. We left at 8.30 in the morning and only got back here (Van Rhynsdorp) after 10 o'clock last night." My son, on being informed of these difficulties, put the matter to Mr. Max Burger, the Irrigation Engineer stationed at Klaver, who, knowing the conditions, arranged for an expert driver, thoroughly experienced in motoring through sand, to take me over the desert road, with the result that no time was wasted on the journey.

My party consisted of Mr. Max Burger, Mr. Hubert P. Hancock, Lance-Corporal John Kirby, Lance-Corporal Denis Hunt, Mr. G. J. N. Coetzee (our " sand " driver) and myself. I carried with me complete photographic equipment. I arrived at Klaver on Monday, 30th September, 1940, at 5.30 a.m., and, after a quick breakfast at the hotel, met the other members of my party and set out for the cave at about 6.30 a.m. The following description of our journey to the Heerenlogement was written by my son, who also acted as " clerk " when we embarked upon the somewhat lengthy process of deciphering and taking down the numerous names.

> " From Klaver we passed over the East Bank Canal and along the main road to Cape Town which runs along the western foot of the Gifberg Range. After about four miles we turned off south-west on to a farm road, and drove a further three miles to Krantz Siphon, where the Canal divides, one half crossing the Olifants River to form the East Bank Canal. Leaving our car

> we crossed the Siphon bridge on foot and ascended the left bank of the river. We then boarded a half-ton Dodge "pannetjie" which was waiting for us, and which was necessary because high clearance is required on the bad roads which were ahead. From the Siphon the road runs southwards up and down over the shale outcrops on the west bank of the Olifants River, crossing the main Canal several times before running into Trawal. The river was in sight the whole time, but there was practically no vegetation outside the river bed. Trawal is a farm settlement consisting of a few unbaked brick cottages, a store and a Post Office. From Trawal we turned west-southwest, crossed the Canal for the last time and ascended a long hill, the road being very rough and sandy in places. The hillside was peculiar in having more vegetation than usual, and *Protea* was fairly abundant. From the top of the hill we overlooked an enormous plain, and in the distance we could make out the sea. The road now dropped down in a south-westerly direction to Skurfkop, a railway siding with a store and a couple of ganger's cottages. This place serves most of the farms situated on the sandy plain, on which the chief crop seems to be wheat. In crossing this plain, westwards, we passed for about three miles through a strip of veld which was ablaze with wild flowers, chiefly orange, white and blue. The road was very sandy, and our tyres had to be partially deflated or we should never have got through the sand. We passed through two or three very fine wheat farms. After crossing this plain we ascended another very steep hill, from the top of which we could again see the sea, this time very clearly and for a considerable distance along the coast. From this point also we could see Mr. W. J. de Villiers' farmhouse just below the cave. The road dropped crazily over rocks and boulders to the farmhouse about five hundred feet below."

Having arrived at the farmhouse we got down from our lorry and, having obtained the key (for the cave is now enclosed by an iron fence and a locked gate), we set off to climb the mountain, passing on our way the famous spring, which forms a pool of considerable size close to the farm buildings. On the side of the mountain we could see the curious rock which contains the cavern, and I photographed it from the edge of the pool.

We then ascended the mountain-side, the rock apparently growing larger and larger as we approached it, until we could clearly see the entrance to the cave. Just inside the gate we observed the notice-board erected on behalf of the Historical Monuments Commission, placed, curiously enough, with its face away from the approaching visitor.

The floor of the cave we found to be practically level, and formed of gravel. At the back of the cave could be seen, in a fissure of the rock, the famous tree which has been described by several travellers, while to the left, on the north wall of the cave, were the numerous names, the bulk of which had been incised in the quartzite of which the rock consists. Several other names could be made out on a flat rock outside the cave proper, and the vestiges of one or two others peeping out from under the plaque secured to the rock on behalf of the Historical Monuments Commission.

As it was obvious that there were many more names on the rock face than any previous visitor had even suggested, I began at once systematically to make as complete a list as possible, taking down every observable detail, whether of apparent relevance or not. In this I was ably assisted by others of the party, two being Dutch-speaking and two English-speaking.

Many of the names and dates could be read with ease, but some caused great difficulty. Here and there new names tended to obliterate older ones, and in places names had apparently been erased, though whether this was due to weathering or to human interference I could not say.

It took us over two hours to decipher and transcribe all the names, dates and sets of initials, and after this work was completed and checked, I photographed the rock face first as a whole and then in sections, in order that doubtful transcriptions might be re-checked at leisure. I also photographed the tree growing in the fissure, the view of the flats below the mountain from the entrance to the cave, and the rock itself from a point not far from the entrance.

On the south side of the rock we found another, though smaller, cave, on the walls of which were a few crude rock paintings, but no names.

Having thus collected all the data that could be obtained on the spot, I returned with my party to Klaver by the same route by which I had reached the cave; a route which, if the driver knows and understands it, is infinitely more expeditious than the regular road.

It now remained for me to examine and classify the material that I had obtained. I first made a loose index of all the names and sets of initials, and, separating those with dates from those without, I arranged the former chronologically and the latter alphabetically .

The earliest names were then seen to have been cut in the rock face in 1712. This, however, did not necessarily mean that the Heerenlogement had not been seen by Europeans before that date; in fact, I had previously found clear evidence that it had been, or at least that the Heerenlogementberg had been so visited.

I therefore returned once more to the pages of Africana, and collected all the references to the mountain and the cave that I could discover, together with such as showed that some particular individual had camped beside, or had passed the neighbourhood of the mountain, even though he did not mention the fact in his diary. I also called on the help of Colonel Graham Botha, Chief Archivist for the Union, in order to attempt to find details of the personnel of some of the early Dutch expeditions to the north, and thus possibly identify a few of the obscurer names inscribed on the rock face. And in order to make certain that I had obtained the earliest possible references to the mountain or the cave, I again consulted the accounts of the earliest expeditions from Cape Town to the north, beginning with that of 1655.

The information thus obtained I have incorporated in a chronological summary which contains the name of every person that I have been able to find who visited the cave, whether he inscribed his name on the walls or not. This summary includes the descriptions of the cave given by several of its visitors, as well as criticisms of some of the travellers who have themselves published partial lists of names from time to time. The undated names and sets of initials have been appended, arranged in alphabetical order.

It will be seen from this chronological summary that a fair number of names have been identified. But many remain, and it is my hope that the summary may be the means of one or other of our historians identifying some of the rest. For example, it ought not to be impossible, with the aid of the names and the precise dates, to identify the persons of those travellers of the early eighteenth century who left their names on the rock. And this is of some importance, since the complete personnel of some of the exploring parties which went north before the time of Hendrik Hop's expedition of 1761 is not yet known.

CHRONOLOGICAL SUMMARY (4).

1655—*Jan Wintervogel* (5) led the earliest expedition to the north and reached Zwartland, where Malmesbury is to-day.

1657—*Abraham Gabbema* travelled north, and reached the Berg Valley.

1659—*Christian Janssen* (*van Hoesum*) travelled north in search of the Namaqua Hottentots, and, reaching the Berg River, followed it to its mouth.

1660-1661—*Jan Danckaert* travelled north, and seems to have reached Clanwilliam. He was therefore within twenty-five miles of the Heerenlogement, and may possibly have seen it. In his party were *Pieter van Meerhoff* and *George Frederick Wreede.*

1661—*Pieter Cruythoff* left for the north ten days after Jan Danckaert's return. He appears to have reached the flats to the north-west of the present day Leipoldtville, where he first met with Namaqua Hottentots. *Pieter van Meerhoff* was again one of the party. The travellers must have passed not far from the Heerenlogement.

1661—*Pieter van Meerhoff* himself led a party northwards. According to Mossop, " this time he went north into the waterless country beyond the great fish-hook curve which the river makes to reach the sea." He seems to have again searched for the Namaqua in the direction of Leipoldtville.

1661—*Pieter Everart* travelled north, with *Pieter van Meerhoff* as a member of his party. Everart left Van Meerhoff encamped on the banks of the Olifants River, near Koekenap, while he himself proceeded north " towards Nieuwerust," and also journeyed to the mouth of the Olifants River. On his way north he must certainly have been within easy distance of the Heerenlogement, if he did not actually pass the spot.

1662-1663—*Pieter Cruythoff* again travelled north, and once more *Pieter van Meerhoff* accompanied him. So also did *Frederick de Smit,* who kept the journal of the trek. Cruythoff, having " reached a point on the Oliphants River where it was very broad, and where it ebbed and flowed " went on in the direction of Nieuwerust. This was the first occasion on which a waggon was taken on one of these northern treks, and the travellers buried it at Elands Kloof, where the Elands River joins the Olifants River, about twenty-five miles south of Clanwilliam.

It will be noted that from 1660 onwards Pieter van Meerhoff was a member of all the expeditions, and that from the third of these, in 1661, he was in a position to visit the mountain and the cave. But no mention of either appears in any of the journals of these expeditions.

There now occurs an interval of nineteen years, and after this lapse of time we begin to get definite information about the existence of the mountain, although it is not called Heerenlogement until much later.

1682—*Olof Bergh* led his expedition into Namaqualand. On his way he passed the mountain, but apparently did not see the cave. He seems, however, to have started the fashion of inscribing names upon rocks, for he wrote his own up on a rock at "Berghfonteijn," where the present Klipfontein Post Office now is (6). This spot is only about six miles from Heerenlogementberg, which was duly visited by Bergh, and he gave it the name Dassenberg.

> "Monday, 9th November. Towards evening between 5 and 6 o'clock we arrived below another range of rocky mountains which we had to pass. Here we found another spring of fresh water to which we gave the name Dassenbergh's Fonteijn because we saw some coneys amongst the rocks. Here we outspanned and passed the night." (7)

No mention is made of the cave, and Bergh's name does not appear ever to have been carved there. It will be seen, however, that after a gruelling journey he arrived at the spring in the late afternoon and left again early on the following day. On his return journey he again visited the spring.

> "Tuesday, 8th December. We arrived about sundown at the Dassenberg[h] spring from which we had departed on the 10th November." (8)

Again he arrived in the late afternoon and left again next morning.

On this journey Bergh was accompanied by *Christoffel Henningh* (sergeant), *Hans Jurian Elingh* (sergeant), *Reynier*, *Daniel* and *Rosierick Hermansz* (helmsmen), none of whose names appear on the rock face in the cave or at Klipfontein (9).

1683—*Olof Bergh* again travelled north, and again he passed the mountain, but did not write his name in the cave, although on this occasion he had more time in which to explore, had he wished to do so.

> "Friday, 10th September. We marched, in the first place, straight to the Dassenberg, which we reached at 2 o'clock. We found at a guess barely as much water as when we left there last year and the grass on the veld was quite parched up. We remained for the night there." (10)

On the following morning the party set out again at sunrise, and on the return journey they again arrived at the spot rather earlier, but left again betimes.

> "Wednesday, 13th October. At 4 o'clock we reached the Dassenbergh where we camped for the night." (¹¹)

On this journey Bergh was accompanied by *Christoffel Henningh*, *J. Claudius*, *Rosierick Harmansz*, *Erasmus Jurgiansen*, *Magnius Pietersz* and *Frans Rijckels*, none of whose names appear in Heerenlogement or at Klipfontein (¹²). It is possible that the J. Claudius was the Hendrik Claudius, the physician and botanist who seems to have accompanied Simon van der Stel when he travelled north in 1685.

1684—*Isaq Schrijver*, when still a sergeant, led an expedition "into Namaqualand and penetrated further into the Kamiesberg than had Olof Bergh." (¹³). He must have passed the mountain, but he did not record the fact, and did not inscribe his name in the cave.

1685-1686—*Simon van der Stel* journeyed to Namaqualand with a very large party which included more than fifty white men. He camped by the mountain, which he recognised as one of Bergh's halting-places.

> "Friday, 14th September. From here [Berghfonteijn] we marched away from the plain, which slopes away very gently to the foot of the Dassenberg, so-called on account of the multitude of *dassies* which live among the rocks. It is full of holes and caves, closely resembling some old, dilapidated building. We had to camp at the foot of the mountain because we had this day traversed roads deep in sand, which had greatly exhausted our draught oxen so that they were unable to cross the great height which confronted us. At this camp there was exceptionally good grass, and it was watered by various running streams containing very fresh and agreeable water. The mountain was also abundantly supplied with fuel. This afternoon, while walking over the mountain, the Honourable Commander [Simon van der Stel] shot a *klip-springer*, very like the European roe but much smaller; also a hare with a muzzle like a jackal and a tail like a fox. It was agreeable to the taste and white of flesh . . ."
>
> "Saturday, 15th September. In the morning at 7.30, the weather being misty, we left the above camp and proceeded towards the aforesaid rocky height . . ." (¹⁴)

Simon van der Stel would seem to have arrived at the mountain in the morning, and had plenty of time to look round. His statement that "it is full of holes and caves" suggests that he observed the main grotto and its near neighbour, but as he did not inscribe his name or mention that he saw any written up on the walls, it would appear that none were in existence at that date. He did, however, carve his name, or cause it to be carved, in a cave at Meerhoff's Kasteel. It is no longer to be seen, but it was observed by Rhenius in 1724 ([15]). One of Van der Stel's miners also wrote up the date 1685 above the entrance to the mine shaft at what is now the place known as Springbok ([16]).

On his return journey Simon van der Stel again passed the Heerenlogement.

> "Sunday, 6th January [1686]. In the morning at daybreak, the Honourable Commander sent a sergeant with four carts and a batch of cattle ahead to the Dassenberg to open and clear the springs, which we feared might be choked with grass. The Honourable Commander followed at 2 o'clock in the afternoon [from the Olifants River] with the rest of the train and at sunset we reached the Dassenberg, where we found the sergeant and camped. We found an abundance of grass and water here . . ."
>
> "Monday, 7th January. We stayed here in order to refresh our animals somewhat with the good grass."
>
> "Tuesday, 8th January. We left at one o'clock in the afternoon . . ." ([17])

The year 1685 had obviously had a very wet season, as Van der Stel found much water where previous travellers found little or none. On this return journey he had plenty of time to explore the mountain afresh, had he wished to do so. His silence regarding inscriptions on this occasion would therefore add weight to my previous suggestion that there were none to be seen.

1705—*Johannes Starrenburg* goes north in October, 1705, acting on instructions from Willem Adriaan van der Stel. The only members of his party mentioned by name are *Corporal Willem Brentgens* and *Jan Hartog*, the master gardener. None of their names appear on the rock in the cave. An examination of two passages in Starrenburg's journal, quoted by Valentijn, shows that the party passed close to the mountain.

> "Friday, 30th October. In the afternoon, after advancing about 4 miles, we came into a kloof at the foot of *Tho Koe* near Olof's Fontein, in order to pitch our tent and take our night's rest as it was raining . . ."
>
> "Saturday, 31st October. We got ready early to depart, and left at sunrise in good weather. One could easily perceive that the horses and cattle had begun to be very exhausted through

> poor pasturage and hard trekking. Whereas before we could get to the top of all these heights with 8 oxen for each waggon, now we had some difficulty to pass *Tho Koe's* kloof with 10, although this was not the highest. However, we travelled along a miserable stony sand-track for about 4 miles, and came to the Olifants River." (18)

On the return journey they found the Olifants River in flood. On Sunday, 8th November, it had subsided sufficiently to permit the party to cross it, though with difficulty, and they camped for the night on the western bank.

> "Monday, 9th November. Recommencing our journey at dawn and favoured with a cloudy sky, now and then accompanied by gusts of rain, we came in the afternoon to Olof's Fonteijn, where we pitched our camp anew and took our night's rest."
>
> "Tuesday, 10th November. Departing again at sunrise from our encampment, we took another route along the southern edge of the Thoe-berg in the direction of the Piquetberg . . ." (19)

From these extracts we can readily see that Starrenburg must have observed Olof Bergh's inscription on the rock above the spring at Olof's Fonteijn, the Klipfonteijn of Van der Stel and the Berghfonteijn of Bergh; and though his journal is silent on the point, one would have imagined that he would have remembered the mountain called Dassenberg by the two previous travellers. Doubtless, however, he travelled without a stop from Olof's Fonteijn to the Olifants River, since he left the former at sunrise; and the same must have happened on the return journey, as the journal shows.

1712—Kaje Jesse Slotsbo leads a large expedition to the north. Col. Graham-Botha has supplied me with a brief summary of his report, which does not mention the mountain or the cave, but clearly shows that the route lay past it, and the existence of Slotsbo's name on the rock with the year 1712 clinches the matter. Out of the total of 181 men who participated in the expedition, at least 99 were Europeans, but apart from the name of one soldier, *Matthys Insidlaar,* who was drowned in Ongeluckigen Valley, probably on 18th October, no details of the personnel are available. It is, however, possible that the bearers of the next two names on my list were members of Slotsbo's expedition.

1712—Casp[ar] Hemery. As I have said, this man may have been a member of Slotsbo's party. His surname was given by Mossop as "Hem" (20) and by the Magistrate of Van Rhynsdorp as "Hern" (21). My reading is, however, correct, though I confess that I might not have arrived at it unless I had found Andrew Smith's list of 1828, in which it is also correctly given. The difficulty arose through the fact that Hemery wrote his abbreviated Christian name and the first three letters of his surname on a curved projection of the rock face, and was forced to continue on the adjacent flat surface. Moreover, the last three letters are far less distinct than the others; hence the fact that they have been overlooked. The year, 1712, is perfectly clear. Below the inscription is a remarkable engraving of an elephant, presumably trumpeting, which Hemery seems to have executed. As the flats below the cave were undoubtedly elephant country, I would suggest that the drawing was probably made from life. It will be seen later on that Le Vaillant observed the engraving of the elephant.

1712—I. Sersein. This man may also have been a member of Slotsbo's party. The date 1712 has been written below the name. Both, though clear enough when pointed out, are not easily seen at first, and can be easily overlooked.

The names of Slotsbo, Hemery and Sersein have been engraved on different parts of the rock, and not together; but as they appear to have been the first names to be inscribed this is perfectly natural. Slotsbo and Sersein stood up to write their names and the year, but Hemery, who was more ambitious, seated himself on the ground in order to draw his elephant in comfort.

It should be noted here that Slotsbo wrote his name on the rock above the spring at Klipfontein while on this very expedition, incidentally mis-spelling it Slosbo (^{22}).

1721—I. T. Rhenius. Ensign Rhenius led an expedition northwards in this year. Below his name he has added the date, 1721, 30.Se. On the previous day, 29th September, he had inscribed his name on the rock at Klipfontein. Nothing is to be found in the Archives relative to this expedition of Rhenius.

1724—*I. T. Rhenius.* Ensign Rhenius again led an expedition to the north. This time he did not write his name on the rock, though doubtless he passed by the mountain. But much further north, in the cave which had been previously visited by Simon van der Stel, and in which he had left his name, Rhenius engraved his own, with the date 8th October, 1724. Col. Graham Botha has advised me that "no trace of Rhenius' journal of his 1724 expedition can be found and this despite the fact that it is specifically mentioned that a copy—not the original—had been sent to Holland" (23). Mossop, however, quotes from it, and shows how Rhenius observed the name of Van der Stel in the cave in question (24).

1732—R. I. Abell, Ano 1732, D.3.Jan.

1732—I. E. Blass, 1732, D.3.Jan.

1732—I. M. Zang, 1732, D.3.Jan.

In each of these three cases the complete date is perfectly clear; these three men therefore travelled in company. Mossop gives the first name as Abel, but this is incorrect (25). Here again we have an instance of three individuals writing their names simultaneously on different parts of the rock. There was still plenty of room.

1739—I. P. Giebeler, 24 Sept. 1739. Mossop omits the month and the day of the month, but they obviously belong to the inscription (26).

1739—I. M. Lourens, 24 Sp. 1739. These two men were also travelling in company, but wrote their names on different parts of the rock.

1741—I. A. Losper, 1741, D. 15 Aug. It is interesting to note that on 7th October, 1774, Thunberg the botanist "passed on to Losper's estate, and on the 8th, passing by Peter Losper's . . . farm, we came to Dreyer's estate, near Riebeek castle" (27). "Losper's estate" was between Paardeberg and "Riebeek castle."

1743—V.S.M. See next entry for the date.

1743—G.B.R. A. 1743, Inder. There is no question that these two men, the eleventh and twelfth to engrave their names, were together. The two sets of initials follow one another and are in turn followed by the date.

1747—Jacob Breedt. This man was accompanied by the next on the list, the whole inscription reading Jacob Breedt, 1742, D. 25 October bin ik gekomen alby de heer Jacob Cloete.

1747—Jacob Cloete. See the previous entry.

1752—P. Laubster [*sic*]. This name and date were given by Andrew Smith in his list of 1828 (^{28}), but I could not trace them on the rock. They must therefore have been obliterated deliberately or by accident.

1759—I. A. v. d. Hever.

1761-1762—*Hendrik Hop* travelled north with a large party, and camped at the mountain, but neither he nor any of his men seem to have written their names in the cave.

> "Saturday, 1st August [1761]. We left Ratel-klip, but since our draught-oxen had become very weak by reason of the great heat and the poor pasturage, we were compelled to rest after a journey of a league and a half, at the place called *Heerenlogement.*" (^{29})

Hop left on the following day, but on his return journey, he again passed the place.

> "Monday, 12th April [1762]. We travelled with one of the Company's waggons to the place called *Heeren-logement.*" (^{30})

It is interesting, however, to note that on this expedition was *Johan Andries Ook* [*i.e. Auge*], the botanist, who is described on the official list as "thuynier" or gardener.

1774—*Charles Peter Thunberg.* This great botanist visited the Heerenlogement in 1774, and has given us a very graphic description of the journey thither and the place itself, though he resisted the temptation to add his name to the fifteen or sixteen that he saw on the walls of the cave.

> [25th October, 1774]. "On the 25th, before we reached the Gentlemen's hotel . . .
>
> "In my way to the Gentlemen's hotel, I found a scarce and long-sought for plant, viz., the *Codon Royené*, but did not see more than one shrub of it, which however I think I never shall forget. It was one of the hottest days in summer, and the heat was so intolerable, that we were afraid that our beasts would grow faint and drop down quite exhausted. By this insufferable and tormenting heat our bodies were swelled up, as it were, and our pores opened in the highest degree. The bushes we met with, were covered all over with white, brittle and transparent prickles, which, when my fellow-traveller and I suddenly fell upon them [*Mr. Mason*, an English gardener], and strove which should pluck the most flowers with our naked hands, scratched them in such a terrible manner, that for several days we experienced great pain and inconvenience.
>
> "At length we arrived quite exhausted to the Gentlemen's hotel, which was a vale between the mountains, with a pretty, high hill. Up this hill we had to drive before we could get into another tract of country, which, however, was not very fertile.

> "This place, which is pleasant, being ornamented with a small wood and a rivulet of fresh water, is called the Gentlemen's hotel, because on one side of the mountain there is a large cavern to the westward, like a hall, formed by two rocks, which were hollowed out by the hand of time. I climbed up to it, and found the names of several travellers written on the sides. Near this was another hollow vault, but somewhat less.
>
> "In the former of these caves there was a small fissure, in which a tree, probably a *Sideroxylon*, had taken root, and stood in a very flourishing condition, being above eight feet in height; although it had no more water for its nourishment and support than the trifling quantity that was retained by the fissure in the rainy season . . .
>
> "We set out on the following day . . the road was almost everywhere sandy . . ." (31)

1778—*William Paterson*. On his second journey Lieutenant Paterson visited the cave, but neither he nor his companions engraved their names on the rock during this or his later visits.

> [10th (evening)—11th (morning) November, 1778]. "We continued our journey about twenty miles to the southward (we had crossed the Olifants River), and at night came to a large cove [*sic*], called the Heer Lodsiement (Gentlemen's Lodgings), where we rested till the next day. In the afternoon we proceeded on our journey through a deep white sandy plain . . ." (32)

Paterson was accompanied by a *Mr. van Renan* and *Jacobus Ryke*. It is noteworthy that he did not mention the engraved names.

1779—*William Paterson*. On his fourth journey Lieutenant Paterson again visited the mountain.

> [July, 1779]. "The following day we proceeded on our journey through a large sandy plain, towards the Hier [*sic*] Lodsiement, which is above forty miles distant [he had just left the "Lange Valley"]. At night we came to the Jackals Valley, where, though we found no water, we were obliged to remain for a few hours in order to refresh our oxen, which were much fatigued. About two in the morning we proceeded to the Hier Lodsiement, where we knew there would be water. We arrived at nine in the afternoon [*sic*], and found a peasant who had arrived about two hours before us. I inquired which way he was going, observing he had many Hottentots and a number of guns in his waggon, he told me that his course was towards the Great River, and that he intended to accompany Colonel Gordon, whom I left at the Cape, but expected he would soon overtake us. In the afternoon we directed our course towards the Elephants' River . . ." (33)

1779—*Colonel Robert Jacob Gordon*. Paterson, as will be seen in the preceding entry, had reached the Olifants River, which he crossed. He then adds "In the evening Colonel Gordon arrived" (34). So Colonel Gordon also passed the Heerenlogement, if he did not actually visit the cave. He and Paterson later separated, arranging to meet in "small Nimiqua Land."

1779—*William Paterson.* On his return journey Paterson again visited the spot.

> "On the sixth of December I parted with my hospitable friend *Niuve Houds*, and also convoyed by his two sons through the Elephant's River, which I expected to find impassable. The water was so deep that it came up to our saddles. The same day we arrived at the Heer Lodsiement. I then left the waggon and directed my course through a sandy plain to the house of Mrs. Low, situate in the Long Valley . . ." (35)

The name Nieuwoudt is well known in the Clanwilliam district, and it will be again met with shortly.

1780—I. E. Ludike, 1780, D.29 Oc. Mossop gives this name as J. Eludike (36). There are, however, dots engraved clearly between the I and E, and the E and L. The date, 29th October, is also unmistakeable.

1783—F. Vailant [*sic*]. François le Vaillant has left us quite an elaborate description of the mountain and cave, as well as the first picture of the spot, which, though crude, and doubtless engraved in Europe, gives some idea of the locality. His description is important in many respects.

> [c. 27th July]. "I was now only a day's journey from *Heerelogement* (master's residence), where I should find, I was told, a very abundant spring of water, a most agreeable retreat, and groves and grottos covered with inscriptions and figures. By the description that was given me; it appeared as if a second Angelica, or some Hottentot Medor, had visited and embellished this scene of enchantment. I banished, however, from my mind all this improbable romance, and indulged only in the hope of finding the fountain. My wants were urgent; I looked forward to it, therefore, with longing expectation, and resolved, if possible, to reach it before night. I arrived; I found it; and, with whatever respect the description of it ought to have inspired me, its waters were soon rendered turbid by my Hottentots and cattle. With regard to the grotto, the inscriptions, the creeping shrubs hanging in festoons, all these like a dream vanished on our approach. I saw only a large cavern, which served to shelter me and my caravan. It was spacious and lofty; and being open at the east [*sic*], we were covered without being shut up in it. Situated upon a small mount, it overlooked on one side my camp

and the plain, which, by the uniform and dreary prospect it presented, filled me with melancholy and discouragement; and on the other was joined to an immense chain of dry mountains, extending in the form of an amphitheatre, the nakedness of which, and the different tints of ochre, grey, and white, with which they were variegated, exhibited a view at once terrifying and majestic. The remains of a habitation, now fallen into ruins, attested that the proprietor had been long forced to abandon this wild and unproductive waste. I made preparations for passing the night in the grotto, but I was obliged to share it with jackdaws and wood-pigeons which repaired to it at the close of the day, and perched in hundreds on a tree, the roots of which were implanted in an enormous crevice, while one of its branches overspread the floor of this natural hall. The figures and inscriptions consisted only of a few caricatures of the elephant and ostrich, with the names of three or four travellers who had probably stopped here formerly, to refresh themselves . . .

> "While we were indulged at the fountain of *Heerelogement* with a temporary enjoyment of the necessary refreshments, we did not neglect our usual labours and researches. Among the rocks, and on the mountains which surrounded us, we found abundance of those small quadrupeds called in the country *dassies*, and by Buffon the daman . . ." (37)

Le Vaillant cannot have been in the best of health when he wrote this rather "disgruntled" description. Doubtless the drought had not tended to improve the landscape, and hence he was prejudiced against the place from the very start. His remarks about the drawings and the names are, however, illuminating. The elephant of Caspar Hemery was well in evidence, and one of an ostrich, which I have been unable to trace. Le Vaillant's "three or four travellers" were at least sixteen or seventeen, so there was ample room for Le Vaillant himself to engrave his own name, which he did, omitting the "le" and one "l" from his surname. He describes this episode as follows:

> "Six weeks only had elapsed since I quitted the Cape, yet my oxen were as much fatigued as they had been during my first journey after a march of six months. To give them time to rest themselves and recover their strength, I remained at Heerelogement seven whole days, during which our table occasioned such a consumption of *dassen*, or damans, that even my Hottentots began to loathe them. At length, however, on the fourth of July, the war we had declared against those poor animals ceased, and I quitted the place, after having left my name and the date of my arrival in the grotto, according to the custom of preceding travellers." (38)

1791—A. Meha [*sic*].

1794—C.P.P. See next entry for the date.

1794—C.M.N. D. 9 Maart. This set of initials follows the previous set, and the date for both is therefore the same. Above these two entries, and in a similar lettering, occurs the name I. A. Neethling; but as it is not certain that it belongs to the same date, I have entered it among the undated names.

1795—I.C.S.

1800—I. H. Nieuwoudt. J. H. Nieuwoudt was Heemraad of Clanwilliam in 1823-1824 (39).

1801 [?]—T. Watson.

1806—C. Mostert, den 12 iuny an 1806.

1809—A. Farquhar. He was a Wesleyan missionary.

1812—A. P. Spreeth.

1813—*John Campbell.* This famous missionary passed on the eastern side of the Heerenlogement in October, 1813. On the 9th of that month, at midnight, he arrived at the Olifants River from the north, and having crossed it, proceeded by easy stages over deep sand. On the 12th he neared the mountain.

> "At four p.m. we departed, and did not reach Great Fountain till nine, though only about seven miles distant, for we had deep sand all the way, so much so, that though we had fourteen oxen to each waggon, they had to rest every few hundred yards; several of them, worn out with fatigue, lay down, and with great difficulty were raised up to try it again. The way was beautifully lined with bushes in flower, five and six feet high. I walked the whole stage, and like the poor oxen was greatly fatigued. We happily found good grass and water where we halted, but so tired were our oxen that they tasted neither till next morning, but immediately when they were unyoked, lay down to rest their weary limbs . . .
>
> "13th October. Left the Great Fountain at four p.m. and by great exertion, travelling through deep heavy sand, the waggons reached Vanwik's Place at nine p.m. As usual I walked on foot the whole stage. I was much gratified, while day light continued, by viewing the various forms of the Cedar Mountain, which stood about fifteen miles to the S.E. . . ." (40)

The "Great Fountain" was a spring at the foot of the eastern slope of the Heerenlogementberg. The farm in that district is still called Groot Fontein. Campbell, however, was on the wrong side of the mountain from our point of view; had he been on the other side I am convinced that he would have added his name to the rest.

[18]15[?]—L.E.D. [?].

1816—B. Shaw. Rev. Barnabas Shaw left Cape Town on 6th September, 1816, accompanied by his wife and Rev. John Henry Schmelen of the London Missionary Society. Schmelen had come to Cape Town to seek assistance for his mission in Namaqualand, and Shaw resolved to make the sacrifice. On 26th September the party visited the cave, and Shaw wrote of it thus:

> "Heere Lodgement (Gentleman's Lodge). We reached this place about midnight. Our cattle having had no water during the day, and the sand being very deep, the croaking of frogs was to all a joyful sound. Here we halted some days to rest our oxen, during which the people were engaged in making bullets for the guns. The fissure in the rock described by Vaillant was visited, and the tree which he mentions, still spreads its branches over the floor of the so-called kliphuis (stonehouse). The names of many travellers are to be seen carved on the rock, some of whom visited the place in 1712. Where are these travellers now? is a solemn question—
>
> "Time, like an ever rolling stream,
> Bears all its sons away." (41)

Shaw arrived at the "Elephant River" on 3rd October, 1816.

1816[?]—R. Jackson.

1817[?]—Hendrik [?] Dams.

1817—*Robert Moffat* left Cape Town with *Kitchingman*, the missionary, and his wife, on 22nd September, 1817, *en route* for Bisondermeide in Namaqualand (42). In all probability he passed the Heerenlogement, although he does not say so himself. Possibly he took the eastern route, as Campbell had done in the reverse direction in 1813.

1819—P. D. Waal, d. 21iuly, 1819. See also the entry for 1823.

1823—Peiter [*sic*] de Waal, den 20 Septr., 1823.

1825—Willem Louw.

1828—*Andrew Smith*. In this year Dr. Andrew Smith visited the mountain, as his manuscript notes on birds prove conclusively, for he mentions it in three entries (43). The date of one of these is the 7th June, a second is undated, while the third concerns his return journey in January 1829. Smith was ostensibly on a scientific expedition, but in reality he was on a government mission to report on the Bushmen of the Orange River for the Acting Governor, Sir R. Bourke (44). He seems to have spent a considerable time in the neighbourhood of the mountain, for he was on the "Kanakaberg" in May, and this range is only a few miles from Heerenlogement. He also examined the cave, and made notes about it; I unfortunately have not been able to find these notes, but a paragraph which appeared in the South African Quarterly Journal in 1830 shows that Smith made the first known list of names of any length (45). As the paragraph and list are of some importance, I give it in full.

> "Heer Logement. The following names, amongst others, are inscribed upon the walls of a cave called the Heer Logement, near the Olifants' River:—
>
> J. J. Rhenius, 20 Sept. 1721. [Should be I. T. Rhenius, and 30th, not 20th.]
> J. P. Grebeler, 24 Sept. 1739. [Should be I. P. Giebeler.]
> P. Laubster, 1752. [Not now to be found on the rock.]
> F. Le Vaillant, 1783. [Should be F. Vailant, 1783.]
> K. J. Slosbo, 1712. [Should be K. I. Slotsbo, 1712.]
> G. A. Warner. [Should be G. A. Wasner.]
> F. M. Lourens, 24 Sept. 1739. [Correct.]
> L. D. Bruys. [Should be L. D. Bruyn.]
> Caspar Hemery, 1712. [Correct.]
> J. A. Lospur, 1741. [Should be I. A. Losper.]
> Jacob Bredt, 1747. [Should be Breedt] ben ik de Kopman al; by de Heer.
> Jacob Cloete. [See my corrected version.]

It will be seen that this list contains twelve out of the twenty-two names that Smith saw upon the rock; his own list may have been complete, and only a selection printed. But, with two exceptions, and a possible third, the names are incorrectly spelled. To what extent the errors are due to the printer I cannot say; but I must admit that spelling was not a strong point with Smith. Smith did not write his name on the rock.

1829—*Andrew Smith* visited Heerenlogement again in January, 1829, as is shown by his notes on birds (46).

1829—K. Zeyher. The famous botanist.

1829—I. Archer, D.CBR [December] 16, 1829. On the flat stone outside the cave.

1830—*C. F. Drège.* This botanist visited the mountain on 25th July, as his autograph diary, still unpublished, shows. He did not engrave his name if, indeed, he saw the cave, for he does not mention it.

> "That night [24th July] I slept at Jan van Zyl's and early in the morning a [native] boy came to fetch Baas Jan and his wife to her sick sister, the wife of Gert; she is suffering from phthisis. Jan van Zyl's servant brought two spans of young oxen. Twice they got stuck in the deep sand. We drove as far as Heerelogement, which is a cattle post. We travelled on with our oxen until close to a koppie belonging to the Knakabergen, and we stationed ourselves close to Piet van Aarde's cattle post in a cave." (47)

1834—E. Cook. Rev. Edward Cook was a Wesleyan Missionary. He inscribed his name while on his first journey to Namaqualand (48).

1834—D. Callaghan.

1834—L. M. Greef.

1834—B.O. [?].

1836—J.E.A. This was Captain James Edward Alexander, the explorer. Professor Pearson, in his article, wrote: "It is interesting to note that Alexander himself resisted the temptation to leave a similar record of his visit." Alexander's own account is worth quoting in full.

> "We journeyed onwards through flower decked coppices [the season was rainy], with a range of party-coloured mountains on our right. We arrived at Heere-logement (or Gentlemen's Lodging), where was a pool of water, under a hill, some distance up which is a large and open cave, or klip-huis.
>
> "A small tree grows out of the fissure of the rock above, and partly overshadows the floor of the cave; whilst, on the north side, is carved the names of travellers and hunters, from the year 1712 to recent periods. Among others, conspicuous, is that of the renowned
>
> F. VAILANT, 1783.
>
> Looking from the cave in a westerly direction, the eye ranges over a wide extent of plain, on which bushes are scattered.
>
> "On the first of October we were on the banks of the Olifants River, which ran full and clear between steep banks which were lined with mimosas and willows. Elephants have long since disappeared from this locality; the only traces of them being the name of the river and the rude figure of one I had seen carved in the kliphuis at Heere-logement." (49)

It is worthy of note that Alexander copies Le Vaillant's inscription accurately, and that the carved elephant which he mentions was that engraved by Caspar Hemery in 1712. Alexander again passed the mountain on his return journey, for in the "Itinerary" the name "Heerelodgement" [*sic*] occurs at that time (50).

1836—J. Jackson. Rev. J. Jackson succeeded Richard Haddy [see below among undated names] as Wesleyan missionary at Leliefontein (51). He engraved his name on his first journey to the mission field.

1837—I. T. Cook.

1839—Adam Lamerd.

1839—J. Tindall. This was Rev. Joseph Tindall of the Wesleyan Missionary Society (52).

1840 [?]—F. M. Luyt, 12.3.1840. See also the entry for 1843.

1840—*James Backhouse.* In March of this year, James Backhouse, the Wesleyan Missionary, visited the cave on his return journey from "Lily Fountain" to Cape Town, he having reached the latter place, a Wesleyan Mission Station, from the south-east. Although this was his first visit to the cave he did not inscribe his name on its walls; but he wrote an excellent description of the locality in his diary.

> "Before five in the morning, we again set forward; as we descended the Knagersberg, the beams of the moon were distinctly to be seen glittering on the sea, near the mouth of the Olifants River. At eight o'clock we reached the rugged, isolated, sandstone hills of the Heerelogement, **Gentleman's Lodging,** where there was a slender spring, supplying some pools of water. At this place, there is a cavernous opening, with perpendicular sides, among the rocks, on the ascent of a lofty hill; on the sides of the cave, the names of several persons were inscribed; among them were Casp. Hem. 1712, with the figure of an elephant underneath, and F. Vaillant, 1783. Elephants are not now met with in this part of Africa, nor on the western side, much to the south of the Tropic of Capricorn. A wild fig-tree hangs into the top of this cave, and gives it a pretty appearance. The adjacent country is so destitute of water, that a wagon, which was here from Clan William, going to a ship, lying near the mouth of the Olifants River, and which left this place after noon, to-day, would reach its destination to-morrow morning, load during the day, and return the following morning, without the oxen having the opportunity of drinking till they should again reach this place; the trader was taking some casks of water with him for the use of the merchant at the ship." (53)

It will be noticed that Backhouse mis-read the name of Casp. Hemery, and also put an extra "l" in the name of Vailant.

1842—J. Foster. (See also the entry for 1846.)

1843—F. M. Luyt, 25.3.1843. (See also the entry for 1840.)

1843—J. Morris.

1843—A. V. Schlicht.

1843—B. Ridsdale [13th December]. Rev. Benjamin Ridsdale, the Wesleyan Missionary, has left an amusing account of his visit to the cave, which occurred while he and his wife were travelling north in company with Rev. H. Tindall. Mr. Richard Haddy and his family were following them, *en route* for Nisbett Bath. Haddy did not trouble to inscribe his name on this occasion, but waited until 1848 to do so. Ridsdale writes on 13th December:

> "About midnight we arrived at *Heere Logement*, 'Gentleman's Lodging,' extremely fatigued with long journeying through deep and heavy sand, and with the intense heat of the day. But though the day had been so hot, we were now quite nipped by the strong keen wind that was blowing. Having arrived so late, and men and oxen being jaded, we took no morning stage on Thursday the 14th, but after breakfast went on an expedition to the famous 'Logement,' or cavernous chamber, from which the place takes its name. After ascending a steep hillside, thickly overgrown with bushes, at about one hundred feet above the plain, we came to a large cavern in the side of the rock, forming a tolerably spacious apartment. Through a fissure in the rocky roof a wild fig-tree sends its spreading branches, giving a pretty effect. On one side of this cavern, full open to the daylight, the names of many travellers and missionaries were cut. [There were 47.] And here I spent some time chiselling my name into the hard face of the rock, a process which I found required much patience, as the rock was of granite. [He was wrong; it was of quartzite], and the only instruments available were a hammer and an old blunt screwdriver. I succeeded quite to my own satisfaction, considering the sorry tools at my command, and left my name, as Brother Tindall said, 'in superfine London type.'" (54)

(See also H. Tindall in list of undated names.)

1845—A. Searle.

1845—[?] Olding.

1845—P. C. v. Ellewee, 18th January.

1846—F. C. Bain.

1846—J. Foster. (See also the entry for 1842.)

1846—J. Gibbs.

1846—W. Smith.

1847— —. Fannin. The grandfather of Dr. Austin Roberts, of the Transvaal Museum, Pretoria.

1847—J. J. Turpin, 29th July.

1848—H. V. Sittart.

1848—R. Haddy. Rev. Richard Haddy of the Wesleyan Missionary Society. See also the entry for B. Ridsdale, 1843.

1849—L. Leygonie. See the following entry.

1849—J. P. Philip. This and the above name occur together, preceded by " Vive L.F.," and connected by " et." I would suggest that the former stands for "Vive la France."

1850—J. Young, February.

1850—J. Gray.

1850—C. Taylor.

1850—W. B. T[ur]pin.

1851—H. Lea (Lt.), December [?].

1853 [?]—G. Prince.

1853—H. Spencer.

1853—W. F. J. Baron von Ludwig. Professor Pearson calls him " a well known plant-collector and cultivator, the founder of a private botanic garden in Cape Town " (55). This is incorrect. It was Carel F. H. von Ludwig, his father, who founded the garden.

1854—J. L. Sharp, 17th July.

1854—R. N. Arling.

1854—A. G. Bain. Andrew Geddes Bain, the so-called " Father of South African Geology." Bain did not engrave his name, but wrote it up in white paint.

1854—J. Calvert, C.E. This and the two following names are painted in red within a red triangle.

1854—J. Lycott.

1854—J. Southgate.

1854—T. Watson.

1859—L. Beck.

1861—Mrs. Fryer, 23rd February. This name and the four following names were written at the same time. Arrowsmith's map of South Africa of 1842 shows " Fryer's Fontein " north of the Orange River.

1861—A. Fryer.

1861—E. Fryer.

1861—M. Fryer.

1861—A. Borcherds.

1861—M. Kekewich.

1867—P. J. A. de Villiers.

1868—T. D. de Villiers.

1868—H. L. Spindler. This and the three following names were written at the same time.

1868—W. A. Spindler.

1868—M.v.W.

1868—S.J.R.

1869—A. Turner, April. This and the two following names were written at the same time.

1869—C. A. von . . .

1869—A. N. von . . .

1870—L. Marquard, 23rd November. (See entry for 1872.)

1871—J. L. Burk.

1872—L. Marquard, 29th September. (See entry for 1870.)

1874—J. B. C. Knobel.

1876—A. Farquhar, 5th March. This and the succeeding name were written at the same time.

1876—L. Bay [?].

1876—J. C. de Villiers, 15th June.

1876 [?]—A. Dittner.

1877—Dr. Fisk.

1879—J. P. v. Ellewee, 1st February.

1881—Jr. P. J. A. de Villiers. (See also 1921). This and the succeeding name were written at the same time.

1881—B. D. Bouwer.

1882—L. J. Colyn [?] 25th [February?]. See the three following entries.

1882—Mrs. A. de Villiers, 25th February.

1882—W. J. de Villiers, d.t. 25th [February]. The farmer living at the Heerenlogement itself.

1882—A. L. Marais, 25th February.

1889 [?]—P. Fleischer.

1892—C. Foster, 12th July.

1892—J. W. Maars [?]. Written in yellow paint.

1894—J. W. Smit, 5th August.

1895—F. G. Coetzee.

1901—J. M. Bennie [September?].

1901—E. Jansen.

1902—M. Brink.

1902—P. S. Krige.

1905—A. Albrecht. See also 1907.

1905—[No name] . . . 30th [?].

1907—A.A. Possibly A. Albrecht.

1907—F. A. de Villiers. (See also 1922.)

1911—Sarie [?] Nieuwoudt, 8th July.

1911—H. E. Smit.

1911—*H. H. W. Pearson.* (See Introduction to this paper.)

1913—P. J. A. Smit, 30th April.

1915—C. Engelbrecht. This and the following name were written at the same time.

1915—R. Osborn.

1921—P. J. A. de Villiers. (See also 1881.)

1921—G. Engelbrecht.

1921—J. H. Smit.

1922—F. A. de Villiers. (See also 1907.)

1927—*E. Mossop*, September. Dr. Mossop did not engrave his name, but photographed a portion of the rock.

1931 [?]—G. Smit.

UNDATED NAMES.

Albrecht, C. Rev. Christian Albrecht, of the London Missionary Society, died in 1815. If this was he, he must have visited the cave before that year, which agrees well with the time when he was stationed in Namaqualand

Bloos [?], H. E.: Bruyn, L. D.; Busche, I. O.; Coutet XX*; De Pass, A. [?]. De Pass and Spence were associated with the Guano Islands.

De Villiers, C.; De Villiers, C. G.; Dieningen, I. V.; Engelbrecht, Christian. (See dated entry for 1915); Engelbrecht, Sypie, 13th July, but no year given; Frens [?], C.; Gadd, M.; Janning, J. Same paint used as by Van Sittart on dated list; therefore possibly 1848.

Lockhart, T. Not "Lockhatt" as in Mossop's list; Mans, G. J.; Malan, J. Executed in yellow paint; Neethling, I. A.; Nicholson, J.; Nicholson, R. G.; Phil, S. H.; Quin, W. R.; Ryneveld, W.; Smit, Mimie, geboren 18 . . . 1911.

Tindall, H. Rev. Henry Tindall, of the Wesleyan Missionary Society, accompanied Benjamin Ridsdale when he visited the cave in 1843. Ridsdale did not say that Tindall engraved his name at that time, but it is quite possible that he did.

Turn, A.; Van der Merwe, M., geb. 22nd June, 1918; Van Zyl [?]; Van Zyl, A. M.; Van Zyl, B.; Van Zyl, D.; Vermeulen, J. N., geb. 1909; Weber, P.; Wicht, J. H.; Wilson, G.; Wolfaardt, E. H. P. He was Field Cornet at the mouth of the Olifants River in 1822-1823, and Heemrad at Clanwilliam in 1827. (55)

UNDATED INITIALS, ETC.

J.M.B.; C.H.; B.A.I.; L.M.M.; H.N.; I.P.; M.P.; C.D.V.; H. de W.; W.V.W.; D.V.Z.; J.V.Z. (On the flat stone outside the cave); Ann; Betty.

These three lists complete the names that I have been able to decipher, though there are signs of others visible which may possibly be recognised later.

In all there are 130 dated names and sets of initials; 30 undated names, of which 5 can be dated approximately, and 14 sets of initials undated.

Altogether there are over 170 names of visitors to the cave, and, as we have seen, not a few distinguished travellers examined the place, but did not record the fact on its walls.

Note.—From the superficial deposits within the cave, my son, John Kirby, collected stone implements and debitage (factory site waste), ostrich egg shell beads in various stages of manufacture, and teeth of animals that no longer live in the neighbourhood. These I handed over to the Bureau of Archaeology, where they were identified by Professor C. van Riet Lowe. They show that the Heerenlogement was once occupied by men of the Late Stone Age.

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   Mossop, E. E.: *Old Cape Highways*, Cape Town, pp. 158-159, and Plates facing pp. 119 and 157.
2. Pearson, H. H. W.: "Le Vaillant's Grotto at Heerenlogement." *The Geographical Journal*, XXXIX, No. 1, pp. 40-47, with sketch map and three photographs (1912).
3. *The South African Quarterly Journal*, Note in No. 2 (Jan.-Apr. 1830), p. 221 (1830).

4. On the *Topographical Map of the Union of South Africa*, Sheet 9, will be seen the following extraordinary statement: "Heerenlogement Cave visited in 1653 by Van Riebeek." The statement is, of course, quite untrue.
5. The persons whose names are printed in italics did not engrave their names upon the wall of the cave, though many of them visited the spot, or at least were in its neighbourhood. For the first eight entries I have drawn upon Mossop's *Old Cape Highways*, checking his statements, wherever possible, from the documents which he consulted.
6. Mossop, E. E.: *Old Cape Highways*, Cape Town, pp. 157-158, and Plate facing p. 184.
7. Mossop, E. E.: *Journals of . . Bergh . . . and Schrijver, etc.*, Cape Town, 1931, p. 99.
8. *Ibid.*, p. 135.
9. *Ibid.*, pp. 78-79.
10. *Ibid.*, p. 153.
11. *Ibid.*, p. 173.
12. *Ibid.*, pp. 190-191.
13. *Ibid.*, p. 196.
14. Waterhouse, G.: *Simon van der Stel's Journal, etc.*, Dublin, 1932, p. 121.
15. Mossop, E. E.: *Old Cape Highways*, Cape Town, p. 158, and Plate facing p. 184. The date was 1721, as is seen on the Plate, and not 1724, as in Mossop's text.
16. *Ibid.*, p. 169, and Figures on pp. 163-164.
17. Waterhouse, G.: *op. cit.*, p. 153.
18. Valentijn, F.: *Oude en Nieuw Oost-Indien*, Dordrecht, Vol. V, (1726), p. 96.
19. *Ibid.*, p. 99.
20. Mossop, E. E.: *Journals of . . . Bergh . . . and Schrijver*, etc., Cape Town, 1931, p. 185.
21. In a letter written to the Secretary of the Historical Monuments Commission.
22. Mossop, E. E.: *Old Cape Highways*, Cape Town, n.d., Plate facing p. 184.
23. In a letter to the writer dated 19th November, 1940.
24. Mossop, E. E.: *Old Cape Highways;* p: 169.
25. Mossop, E. E.: *Journals of . . . Bergh . . . and Schrijver, etc.*, Cape Town, 1931, p. 185.
26. *Ibid.*, p. 185.
27. Thunberg, C. P.: *Travels in . . . Africa, etc.*, London, Vol. II, pp. 136-137.
28. *Vide infra* "Andrew Smith."
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30. *Ibid.*, p. 2.

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33. *Ibid.*, pp. 101-102.

34. *Ibid.*, p. 102.

35. *Ibid.*, p. 131.

36. Mossop, E. E.: *Journals of . . . Bergh . . . and Schrijver, etc.*, Cape Town, 1931, p. 185.

37. Le Vaillant, F.: *New Travels into the Interior Parts of Africa, etc.*, London, 1796, Vol. I, pp. 215-217 and p. 218, and Plate facing p. 216.

38. *Ibid.*, pp. 221-222.

39. Cape Almanacks (1823 and 1824).

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43. Andrew Smith, Manuscript Notes on Birds, housed in the Transvaal Museum, Pretoria.

44. Kirby, P. R.: *The Diary of Dr. Andrew Smith*, etc., Cape Town, Vol. I, 1939, pp. 14-15.

45. *The South African Quarterly Journal*, Cape Town, 1830, Note in No. 2 (Jan.-Apr., 1830), p. 221.

46. See Reference No. 43.

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50. *Ibid.*, Vol. II, p. 279.

51. Whiteside, J.: *History of the Wesleyan Methodist Church of South Africa*, etc., London, 1906, p. 58.

52. *Ibid.*, pp. 60-61.

53. Backhouse, J., *A Narrative of a Visit to the Mauritius and South Africa*, London, 1844, p. 593.

54. Ridsdale Benjamin: *Scenes and Adventures in Great Namaqualand*, London, 1883, pp. 22-23.

55. Pearson, H. H. W.: *Op. cit.* p. 40.

56. See Cape Almanacks 1822, 1823, 1827.

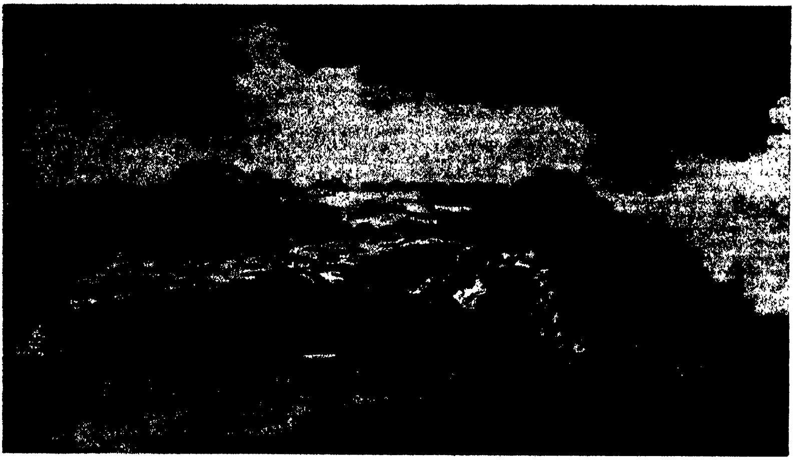


Plate 1-A. Heerenlogement (after Le Vaillant).

Plate 1-B. Heerenlogement. The spring and the rock.

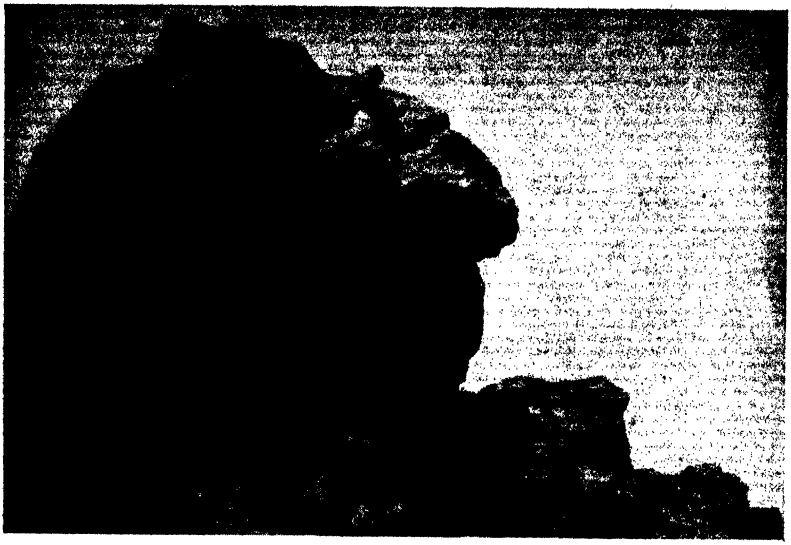


Plate 2-A. The Rock, showing the cave.

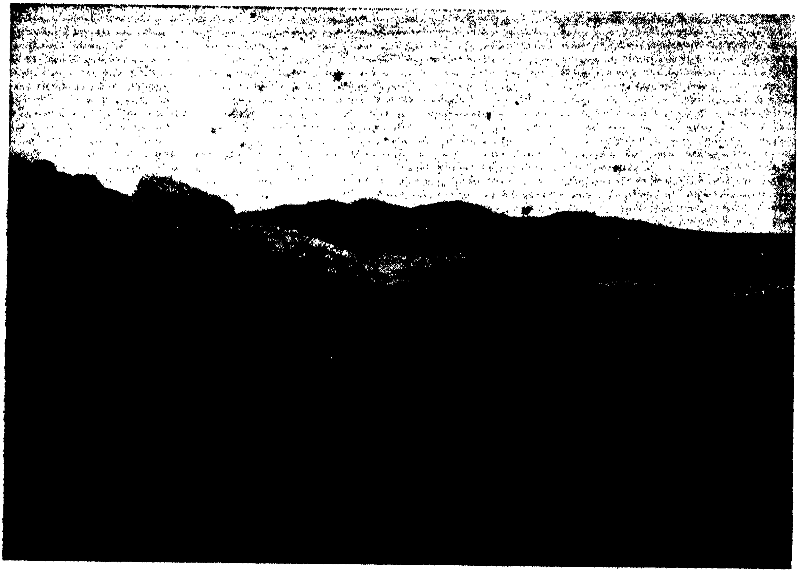


Plate 2-B. View from outside the cave.

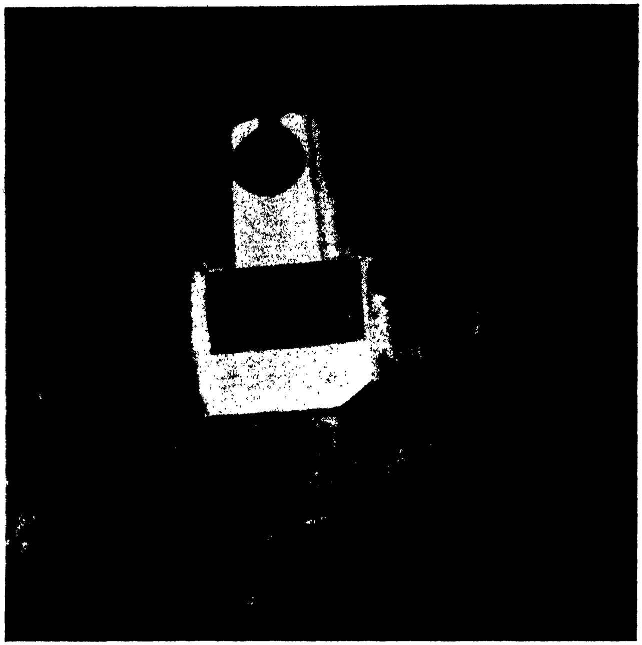


Plate 3-A. The plaque of the Historical Monuments Commission

Plate 3-B. The celebrated tree.

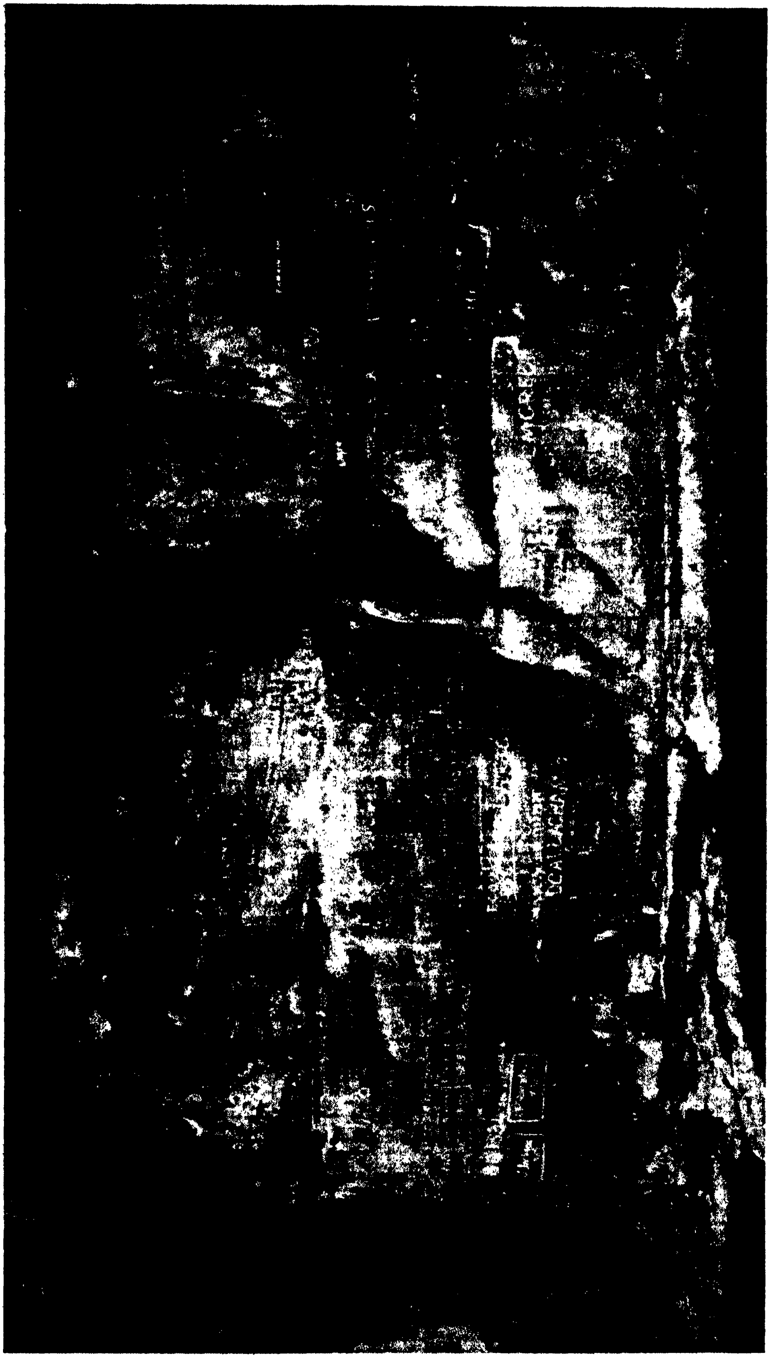


Plate 4. Rock face showing engraved names.

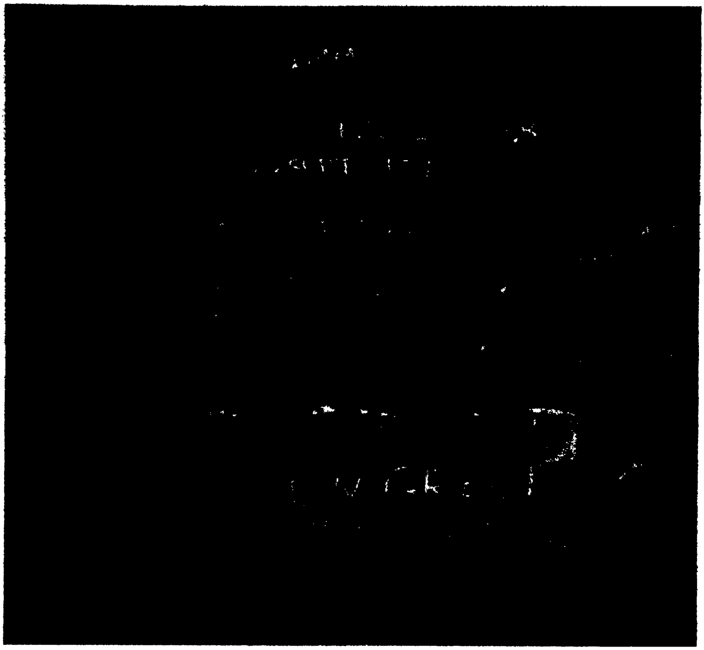


Plate 5-A. Engraved Names.

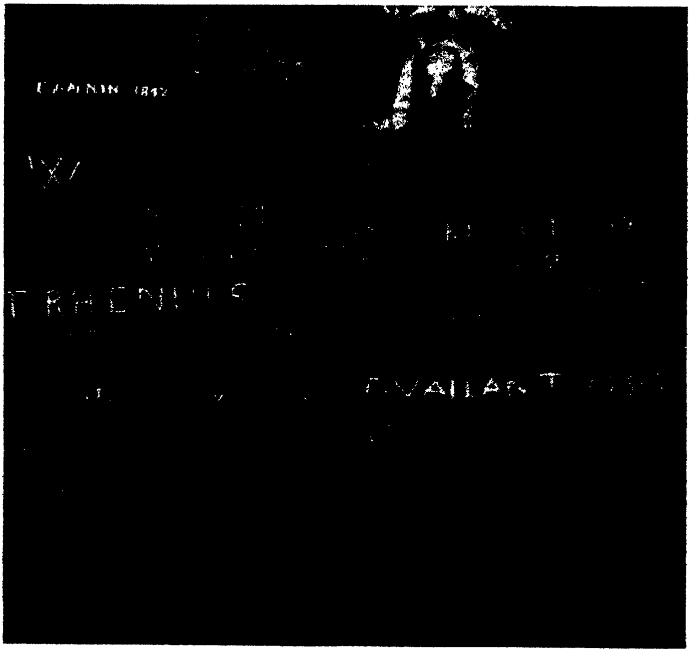


Plate 5-B. Engraved Names.

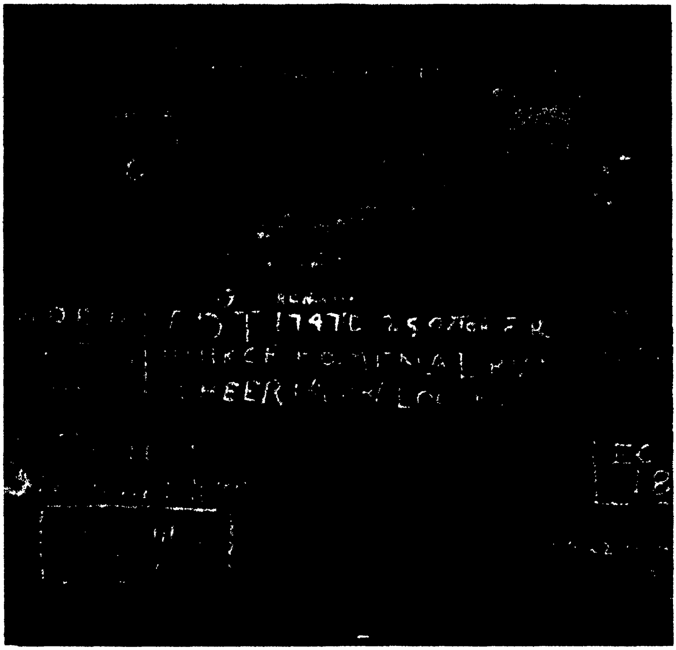


Plate 6-A. Engraved Names.

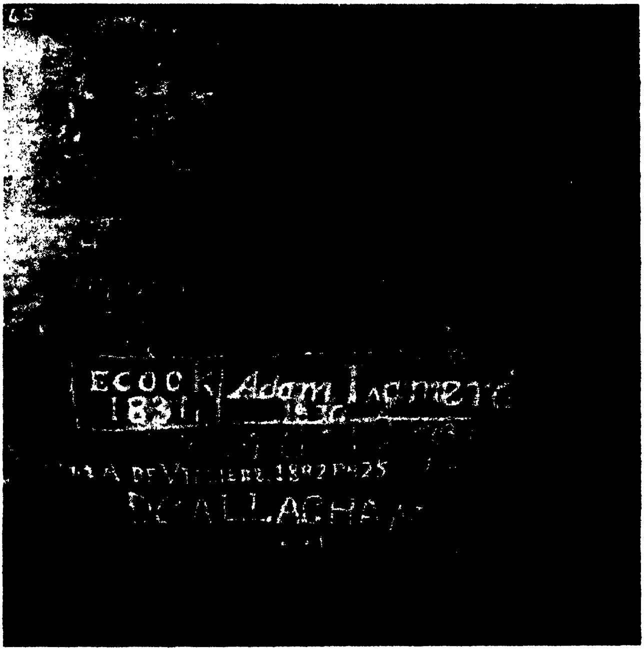
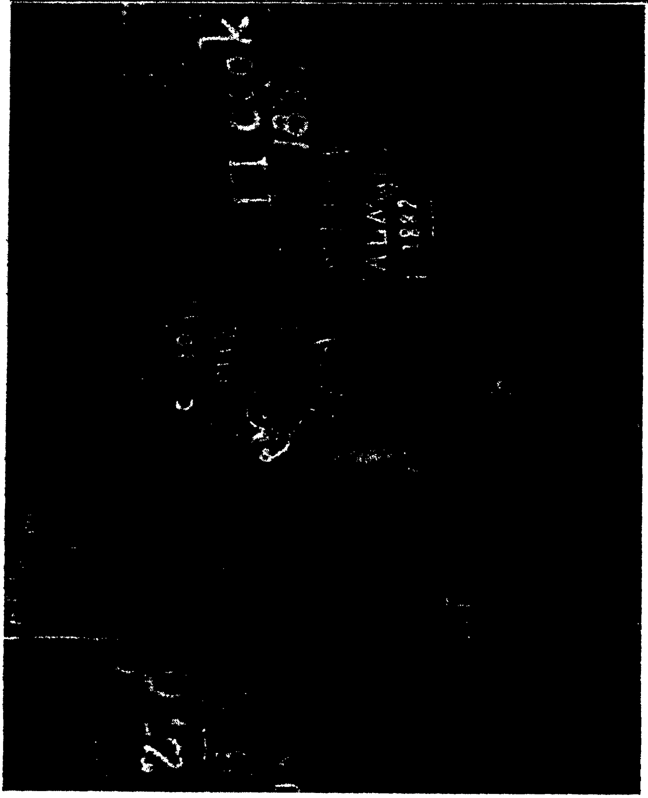


Plate 6-B. Engraved Names.



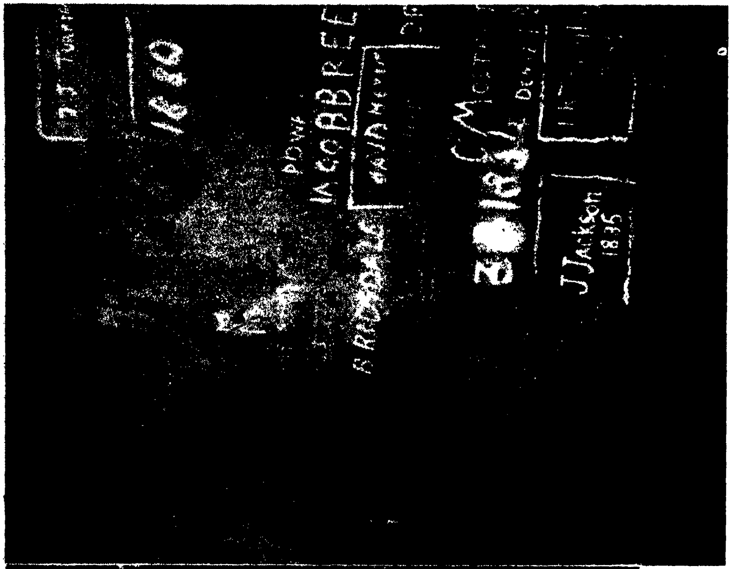


Plate 7-A. Engraved Names.

Plate 7-B. Engraved Names.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XXXVIII*, *pp.* 387-395.
January, 1942.

AN UNRECOGNIZED NEED IN EDUCATION, AN INTRODUCTION TO THE STUDY OF THE TECHNIQUE OF F. MATTHIAS ALEXANDER

BY

I. G. TASKER.

Read 1st July, 1941.

The teaching technique originated by F. Matthias Alexander has been demonstrated in London for the past forty years and is now well-known in Great Britain and the United States where it has received recognition from outstanding members of the medical and educational professions. As it has been brought to South Africa only within the last five years, some account of this technique may be of interest.

The technique has grown and developed with the passing of the years, and Alexander has recorded his experiences in three books, viz., *Man's Supreme Inheritance*, 1910, *2nd edition* 1918; *Constructive Conscious Control of the Individual*, 1923; and *The Use of the Self*, 1931. These books have an introduction by Professor John Dewey, the well-known educational authority, who in his introduction to *The Use of the Self*, describes his experiences when he became a student of Alexander's technique, since which time he has observed its development and growing appreciation.

It is impossible, within the scope of a paper of this kind, to give more than the briefest outline of Alexander's principles and procedures, and to this section of the South African Association for the Advancement of Science it is fitting that John Dewey's words should form the introduction:

> "Mr. Alexander has demonstrated a new scientific principle with respect to the control of human behaviour as important as any principle which has ever been discovered in the domain of external nature. Not only this, but his discovery is necessary to complete the discoveries that have been made about non-human nature, if these discoveries and inventions are not to end by making us their servants and helpless tools . . . I unhesitatingly assert that when judged by the standard of a principle at work in effecting definite and verifiable consequences, Mr. Alexander's teaching is scientific in the strictest sense of the word."

This quotation is from his introduction to *Constructive Conscious Control of the Individual*, and eight years later, when *The Use of the Self* was published, he wrote:—

> "It is a commonplace that scientific technique has for its consequence control of the energies to which it refers. Physical science has for its fruit an astounding degree of new command of physical energies. Yet we are faced with a situation which is serious, perhaps tragically so. There is everywhere increasing doubt as to whether this physical mastery of physical energies is going to further human welfare, or whether human happiness is going to be wrecked by it. Ultimately there is but one sure way of answering this question in the hopeful and constructive sense. If there can be developed a technique which will enable individuals really to secure the right use of themselves, then the factor upon which depends the final use of all other forms of energy will be brought under control. Mr. Alexander has evolved this technique."

Alexander's own account of the researches which led to the evolution of his technique is to be found in the first chapter of *The Use of the Self*. He describes how as a young man he became a Shakespearean actor and reciter, and after a few years was attacked by throat trouble, culminating in a loss of voice which threatened to put an end to his professional career. He consulted doctors and voice trainers and followed various treatments. Nevertheless the trouble persisted. At last his doctor prescribed complete rest from reciting while he followed another treatment, and this time his voice seemingly recovered. He returned to his work and gave another recital and started off quite free from hoarseness, but, to his dismay, by the end of the evening he had completely lost his voice again. His doctor next day could not explain why, although Alexander had carried out his instructions faithfully during the treatment to rest his voice, the hoarseness had returned as soon as he started to recite. Alexander therefore reasoned, "If, when I started to recite, my voice was quite well, and by the end of the evening was as bad as ever, *it must have been something wrong that I was doing myself that was causing the trouble.*" His doctor agreed, but could not tell him what he had been doing wrong, so Alexander decided to try and find out for himself.

He began a long series of investigations watching himself before a mirror. He first observed what he did when speaking in ordinary conversation, and then what he did when he started to recite. He at once noticed that as soon as he started to recite, he tended to pull his head back and down, to depress his larynx and to suck in breath through his mouth. These faults were not apparent in ordinary speaking, so this was his first inkling that there might be *a connection between the wrong functioning of his vocal organs and misuse of the parts concerned.*

From this simple beginning he entered upon a long series of experiments, trying to find some use of his neck and head which was not associated with the faults he had observed, particularly the depressing of the larynx. He succeeded at last in discovering that *a certain use of the neck in relation to the head, and of the neck and head in relation to the torso and limbs conditioned the working of the organism as a whole, constituting what he has called the "primary control."* After a long period of experimentation he succeeded in employing this primary control in his reciting, and in preventing himself from reverting to his old wrong habitual use. The result was, to quote his own words:

> "The marked effect of this upon my functioning convinced me that I was at last on the right track, for once free from this tendency, I also became free from the throat and vocal trouble and from the respiratory and nasal difficulties with which I had been beset from birth."

This is a mere summary of events which are described in detail in *The Use of the Self.* What concerns us here is what Alexander learned in the course of his researches, because the experiences he gained in trying to overcome his difficulties as they arose led him to adopt the principles which are at the base of his teaching technique.

Briefly, his findings were:—

1. That the specific misuse of his neck and head in reciting was not an isolated one, but part of a wrong use of himself generally which was habitual, affecting his manner of walking, sitting, bending, etc. It was only when he found a primary control which conditioned a better use of himself as a whole that he made any improvement in the specific wrong use.

2. That his sense of feeling was utterly untrustworthy as a guide when he tried to employ a new use of any kind. He would decide to do one thing, and on looking in the mirror found that he was doing something quite different; that his use was being misdirected. He tested other people to see whether they were using themselves in the way they thought they were, and found that they, too, were being deceived by their sense of feeling and similarly misdirecting their use.

3. That the misdirection of his use started immediately he reacted to the stimulus to recite. Immediate response meant that he responded instinctively and went wrong.

He therefore decided that he must hold back, i.e., inhibit his immediate response to the stimulus to recite in order to give himself the chance to check the instinctive misdirection, and instead, to project consciously the directions pertaining to the new and better use. By this means only was he able to defeat the influence of his misleading sense of feeling. He had arrived at the principle which is basic to his technique, what he has called the "means-whereby" principle. This is the principle of thinking out the reasonable means whereby a given end can be achieved, in opposition to the old method of working blindly and instinctively for the given end.

Experience in teaching others confirmed these findings. He started his teaching career with professional voice-users and found that any specific trouble with voice production was associated, as in his own case, with misdirection of the use of the whole organism. Working from his "means-whereby" principle, he has never made the amelioration of any specific trouble his "end." He concerns himself instead with the means whereby that end can be attained, which is, in his experience, the improvement of the pupil's use of himself generally through learning to employ the primary control in all activity. Whatever form the specific trouble may take, Alexander first notes the general misuse of the pupil, particularly the nature of his interference with the primary control. Then, by asking the pupil to perform some everyday act, say, sitting down, he points out where he is misdirecting the use of himself in the act of sitting down. To STOP WHAT IS WRONG is the first step in the process. Alexander therefore begins by giving the pupil the directions for preventing misuse of the parts concerned with the primary control, and follows this up by reasoning out for and with the pupil the means whereby a better use in sitting down can be brought about. The pupil then learns to project consciously the directions required for putting these means into effect, but still holds back, i.e., inhibits, his response to the stimulus to sit down. Alexander then proceeds, with his hands, to give the pupil the sensory experience of the new and improved use in sitting down. This experience, from its very unfamiliarity, will at first feel wrong, and the pupil may need the help of the mirror to show him that what he thinks is wrong is in fact right. But by repetition the new experience comes to feel familiar, and if teacher and pupil, in repeating their combined procedure, keep to THE PRINCIPLE OF NEVER SEEKING TO GAIN A RESULT DIRECTLY, but of working out and attending to the means of securing that result, it is only a matter of time for the pupil to become able to maintain the new use of himself. When this stage is reached, the improvement in general use has been found to be accompanied by an improvement in general functioning, and specific troubles to tend to diminish gradually during the process.

Alexander's technique was first brought to the notice of the medical profession in 1923, when Dr. Peter Macdonald, of York, who had become a student of the technique, referred to it at the British Medical Association Conference in the Section of Neurology and Psychological Medicine. Three years later, Dr. Macdonald made Alexander's work the subject of his Presidential Address to the Yorkshire Branch of the B.M.A., and this was published in *The British Medical Journal* of December 25th, 1926, under the title of *Instinct and Functioning in Health and Disease.* In this address Dr. Macdonald drew attention to the relation between Alexander's discovery of a primary control and the work of Rudolph Magnus of Utrecht. He said:—

> "Those of you who know the work of Professor Magnus, of Utrecht, and who have read the most important lecture he delivered at Edinburgh on May 19th and 20th on the physiology of posture, in which, for instance, he points out that in his experiments on 'attitudinal reflexes' 'the whole mechanism of the body acts in such a way that the heads leads and the body follows,' will see how the conclusion of Alexander as to the importance of the relation between head and neck, neck and trunk, is borne out by laboratory experiments. In fact, Alexander has in his work and the technique he has devised for re-educating his pupils anticipated some of the results which Magnus and others have arrived at through these laboratory experiments."

During his many years of teaching experience in London Alexander has had increasing support from medical men who have either been pupils themselves or have sent patients to him for teaching. On May 29th, 1937, a group of nineteen medical men wrote as follows to the *British Medical Journal*:—

> "In a review of Mr. F. Matthias Alexander's book 'Constructive Conscious Control of the Individual' which appeared in your columns of May 24, 1924, your reviewer wrote: 'He (Alexander) would certainly appear to have something of value to communicate to the medical profession.'
>
> "We, the signatories to this letter, are at one with your reviewer in this belief. As the medical men concerned we have observed the beneficial changes in use in functioning which have

> been brought about by the employment of Alexander's Technique in the patients we have sent him for help—even in cases of so-called 'chronic disease'—whilst those of us who have been his pupils have personally experienced equally beneficial results. We are convinced that Alexander is justified in contending that 'an unsatisfactory manner of use, by interfering with general functioning, constitutes a predisposing cause of disorder and disease,' and that diagnosis of a patient's troubles must remain incomplete unless the medical man when making the diagnosis takes into consideration the influence of use upon functioning . . .
>
> Bruce Bruce-Porter, J. R. Caldwell, J. H. Dick, Mungo Douglas, H. Duffett, C. A. Ensor, W. J. Graham, A. Rugg Gunn, Percy Jakins, J. Kerr, D. Ligat, J. E. R. McDonagh, Peter Macdonald, R. G. McGowan, Adam Moss, A. Murdoch, F. J. Thorne, Harold Webb, A. H. Winchester.

During this period children as well as adults came for lessons in the technique, and in 1924 it was decided to start a small class where the children could be helped, as they did their schoolwork, to apply the better use they were in process of learning from Alexander to their daily activities. It was my privilege to direct this little class until I came to teach the technique in this country in 1935. Later, the children's class was combined with that of the Training Course for Teachers which Alexander started in London in 1930 with the co-operation of his supporters in the medical and educational professions.

The outbreak of War caused the cessation of the work in London, most of the members of the Training Course being engaged on war service, but the children's class and Training Course are being carried on at the F. M. Alexander Trust Fund School, Whitney Homestead, Stow, Mass.. U.S.A., where Mr. Alexander and his associates are now resident. A new book embodying the experiences he has gained since he wrote *The Use of the Self* is just about to be published both in England and in the U.S.A.

In order to make clear how the principle and technique of Alexander concerns the education of children I may give a short account of my personal experience as a teacher. I had been teaching for three years after leaving the University when I had a serious breakdown in health. I had read *Man's Supreme Inheritance* and the idea of learning to obtain conscious control appealed to me. I therefore took a course of lessons with Alexander which improved my health to the condition that I was able to take up my teaching profession again. I had always been anxious to study personally under John Dewey, and so when the opportunity occurred, I accepted a post in a school for young children in New York. In this school there was a small boy of eight whom I found quite unteachable from the ordinary teaching point of view. He seemed unable to reason or to attend to what he was doing, although it was evident that he was more than usually well endowed. Alexander was in New York at the time and this boy was sent to him for lessons on account of a bad stammer. By the end of the winter season he had become a reasoning and teachable child and had taken his proper place at the top of the class. This fact led me to think that " If at the beginning of the season this boy was unteachable and at the end, after taking lessons from Alexander became teachable, there must have been something in Alexander's technique which brought about the change." I concluded, therefore, that if there was even one child whom I could not reach by methods which had proved successful with other children, my teaching could not be on a sound foundation, and I decided to give it up and take up some other work. Mr. Alexander on hearing of this asked me to join him as his assistant, and I had that privilege for seventeen years before I came to this country.

It is over a considerable period therefore that I have had the opportunity of observing the effect upon pupils, of all ages and conditions, of learning how to direct the primary control of their use in their activities. But my chief interest has always been in the work with children whose habits of misuse are less fixed than those of adults, and who therefore have less to unlearn. The demand for the technique has generally come on behalf of children suffering from some form of disability. Whether the disability is called " physical," such as flat foot, round shoulders, speech defect, or " mental," such as lack of concentration, slowness at school, slipshod thinking, we have found that the child's general use of himself is always misdirected, more or less seriously. Our procedure is not to aim at the betterment of this specific trouble directly, which would mean working on what Alexander calls the "end-gaining" principle. Instead, we teach that child how to prevent the misdirection of his misuse and help him, through making an improvement in the working of his primary control, to maintain a better use of himself as a whole in everything he does. If in our teaching we keep to the principles I have outlined above as basic to the technique, we find that during the process of improvement in the child's use, there ensues a corresponding improvement in his general functioning and in the quality of his output, during which process his specific disability tends gradually to disappear.

Dr. Peter Macdonald, who had the opportunity of observing the working of the technique in the children's class in London, stated in the address from which I have already quoted: "His (Alexander's) work should be incorporated in the education of our young, if only as a matter of preventive medicine."

We have evidence all around us that present educational methods do not prevent children from developing bad habits of use and functioning in the process of being educated. Striking evidence can be found in a leading article in *The Star*, Johannesburg, dated May 16th, entitled "An Educational Indictment," based on the examiners' report in the Cape Senior and Junior examinations: "Almost illegible handwriting," "slovenly work," "inability to understand the simplest question," being some of the criticisms, and in a second article, dated May 21st, entitled "A Slipshod Crowd," based on a statement made by General Smuts that "We in South Africa are a slipshod crowd, do you ever see young men carry themselves properly in this country?"

Both these criticisms are directed against young people whose education has been based on the artificial separation of the "physical" from the "mental." "Mental" training in the classroom with intervals of "physical" training outside. It does not seem to have worked too well judging by these published reports. As long as we assume that the child's organism can be separated into two parts, "physical" and "mental," and dealt with as such, so long shall we have with us the spectacle of children who, in spite of increased time being given to "physical" drill and exercises, continue to sit slumped in their chairs and to huddle over their desks as they do their "mental" work in school.

The need for change in our conception of education was never so acute as it is to-day. If the results of basing educational method on the old conception of "mind" and "body" as separate entities, are proving so unsatisfactory, might not a change to the conception that the child should be educated as a psycho-physical whole lead to a revolution in teaching methods generally? This is the conception which is fundamental to Alexander's teaching technique for the improvement of use. Every step in his procedure is based upon it as a guiding principle. John Dewey gives his personal experience of it in his introduction to *The Use of the Self*:—

> "And so I verified in personal experience all that Mr. Alexander says about the unity of the physical and psychical in the psycho-physical; about our habitually wrong use of ourselves and the part this wrong use plays in generating all kinds of unnecessary tensions and wastes of energy; about the vitiation of our sensory appreciations which form the material of our judgments of ourselves . . . together with the great change in moral and mental attitude that takes place as proper co-ordinations are established. In reaffirming my conviction as to the scientific character of Mr. Alexander's discoveries and technique I do so then, not as one who has experienced a 'cure' but as one who has brought whatever intellectual capacity he has to the study of a problem . . . . The technique of Mr. Alexander bears the same relation to education that education itself bears to all other activities. It contains in my judgment the promise and potentiality of the new direction that is needed in all education."

Consciousness of need has ever been the first step in the making of change. Might not Alexander's discovery, that it was what he was doing wrong in the use of himself that was standing in the way of his success, prove to be the starting point for an investigation into what lies behind the difficulties and disappointments encountered by all who are engaged in the work of education?

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